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ABSTRACT

These teacher's materials are for a 24-unit competency-based secondary education course on electricity and electronics designed for California public schools. The 24 units are: (1) an orientation; (2) an introduction to electricity; (3) safety; (4) history of electricity; (5) basic electrical skills; (6) magnetism; (7) the nature of electricity; (8) methods of producing electricity; (9) electrical flow through conductors, insulators, and semiconductors; (10) electrical units of measurement; (11) electrical terms and symbols; (12) components, switches, and circuits; (13) resistance and resistors; (14) electric lamps and heating devices; (15) electromagnetism; (16) alternating current and direct current; (17) motors and generators; (18) low-voltage signal devices; (19) circuit protection devices; (20) house wiring; (21) basic electronics mathematics; (22) communications systems; (23) occupations in electricity and electronics; and (24) opportunities in electricity and electronics. Units begin with instructional management information such as time allocation, objectives, evaluation suggestions, references for the instructor, an overview of the unit, presentation hints and suggested methods of instruction, supplemental activities, and a list of the contents of the unit. Other elements provided for the units include a lecture outline, tests, answers to tests, technical glossaries, student worksheets that are pencil-and-paper exercises and activities, and informational handouts. (CML)

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Electricity – Electronics

Curriculum Guide

Instructional Modules
Level II

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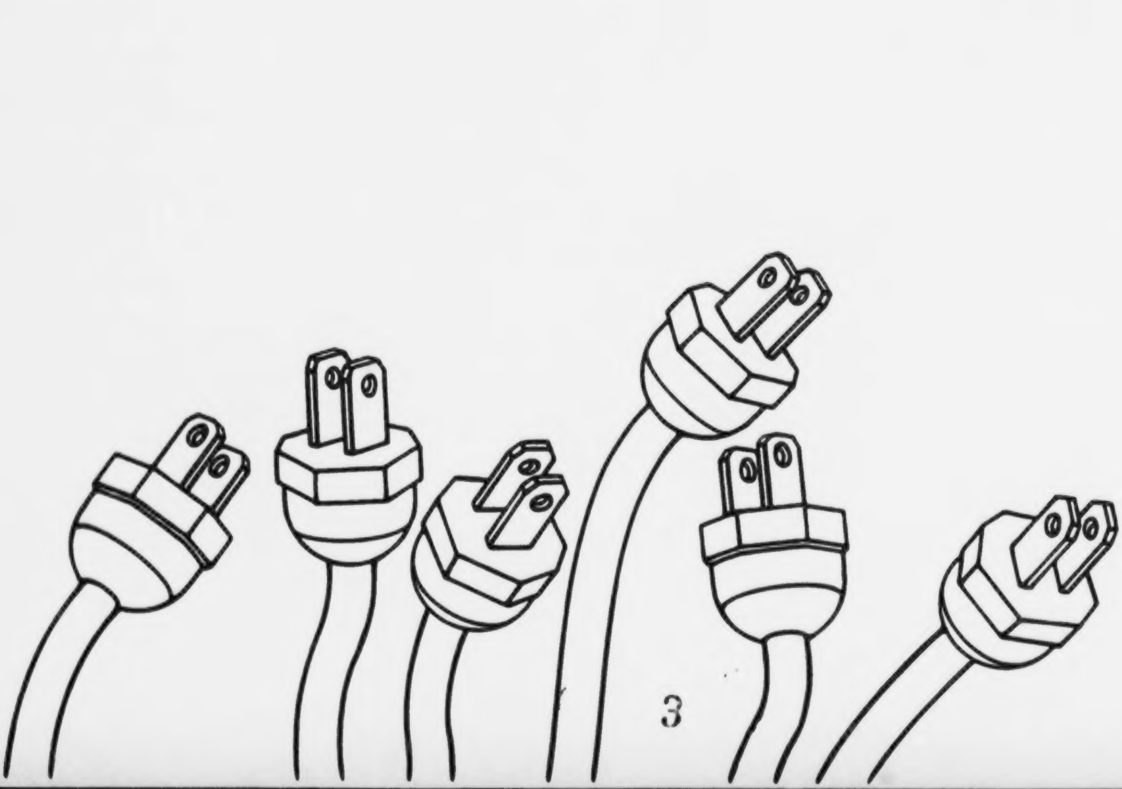

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Preface

Industrial education is a generic term that applies to all levels of education and training offered for industrial occupations in the public schools of California. Industrial education includes the major subject-matter fields of industrial arts, trade and industry, and technical and health careers and services. A comprehensive and reflective industrial education curriculum will help students in selecting, preparing, and advancing in emerging and existing occupations or careers.

Industrial education programs are also those educational programs which deal with the technical, occupational, recreational, organizational, managerial, social, historical, and cultural aspects of industry and technology.

In essence, the industrial education curriculum is intended to help the individual to respond sensitively to technological developments and to cope efficiently and effectively with the consequences in his or her personal life.

To provide skills for students to meet their employment needs in the future, the educational system must meet the curriculum challenges of today. One means of solving this problem is the Electricity/Electronics Curriculum series, which is divided into four levels of instructional units that are based on actual job requirements. Level I is designed to help the instructor in planning, organizing, and presenting introductory electricity/electronics materials to the student. Levels II through IV provide the instructional units, including classroom materials, for a realistic curriculum that can be used in developing student competencies for entry-level occupations and/or technical specializations.

It is sincerely hoped that the educational materials contained in this curriculum will help to improve the instruction in electricity/electronics in California public schools.

SHIRLEY THORNTON
Deputy Superintendent
for Specialized Programs

JAMES T. ALLISON
Director
Career-Vocational
Education Division

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Project Staff

Kenneth Beron, Project Staff Member
Keith Bush, Project Director, Administration
Kirk Harmon and Ben Gonzales, Project Illustrators
Robert Lillo, Project Coordinator, Curriculum Development
Kevin Merrill, Project Assistant
Penny Morgan, Project Secretary and Typist
Nick Soffiotto, Project Staff Leader
Mark Torres, Project Promotional Illustrator

Special Contributors

T. Chris Almeida, Program Manager, Industrial Technology Unit, Career-Vocational Education Division, State Department of Education, Sacramento
Lois W. Bennett, Vocational Education Department, University of Northern Colorado, Greeley
Alex Bentley, District Manager, McGraw-Hill Book Company, Novato, California
Thomas Collins, Assistant Superintendent, East Side Union High School District, San Jose
Wilbur M. Concklin, Principal, Mt. Pleasant High School, San Jose
Robert Crates, Director of Planning and Development, C.T.I. Education Products, Inc., Mt. Pleasant, South Carolina
Charles Elkind, Vice-President, American Electronics Association (WEMA), Los Angeles
Frank Fiscalini, former Superintendent, East Side Union High School District, San Jose
Max Hartdegen, former Administrative Assistant, East Side Union High School District, San Jose
Merl K. Miller, Publisher, Dilithium Press, Portland, Oregon
Clarence Moomau, former Career Services Supervisor, East Side Union High School District, San Jose
D. W. Nurse, President, Schlumberger Products, St. Joseph, Michigan
George Oliver, Manufacturer's Representative, Fremont, California
Larry Tribett, Marketing Representative, Bobbs-Merrill Educational Publishing Company, Pasadena, California

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Introduction

One of the fundamental concepts of industrial education is to use experiences, curriculum, instruction, and guidance to help students prepare for economic independence and to give them an appreciation for the dignity of work. Another purpose is to prepare students for a successful life of work by increasing their options for occupational choices, by eliminating barriers to attaining job skills, and by enhancing learning achievement in all subject areas.

Irrespective of what the future may hold, individuals living in today's society will be handicapped in the job market if they are not reasonably informed about the electrical/electronic technological applications that are used to make our lives richer and more enjoyable. The present civilization is scarcely conceivable without the many electrical/electronic devices that were developed during the industrial growth of this country. The industry has become one of the giants of this century and employs millions of people.

The total impact of electricity/electronics on human life is of such a magnitude that it necessitates a comprehensive technical program in our schools to produce informed individuals capable of functioning effectively in our society.

Purpose of Curriculum

The educational system must meet the curriculum challenges of today so that students can meet their employment needs in the future. One means of solving this problem is the development of an electricity/electronics instructional program with curriculum that is based on actual job requirements. By using this approach, the student is provided with a more realistic curriculum that can be used to help him or her acquire the necessary competencies for entry-level occupations and/or technical specialization.

The basic intent of the Electricity/Electronics Curriculum is to provide educators in industrial education with a competency-based reference that can be adapted or adopted to any existing or new program without major expenditures. Hopefully, the curriculum will be used by educators who desire to revise or restructure their electricity/electronics curriculum. The format of the curriculum provides the flexibility needed for teacher modifications of methodology, instructional resources, textbooks, equipment, laboratory systems, and so on.

Curriculum Levels

The following is a brief description of each level of instruction and its duration:

1. Curriculum Level I—Grades Seven and Eight
   a. Nine-week unit outline
   b. Eighteen-week unit outline
2. Curriculum Level II—Grade Nine
   a. Thirty-six-week unit outline
3. Curriculum Level III—Grade Ten
   a. Thirty-six-week unit outline
4. Curriculum Level IV (Specialization Level)—Grades Eleven Through Fourteen
   a. Thirty-six-week unit outline at each grade level

The contents of the four curriculum levels were prepared to increase the efficiency of the electricity/electronics program in the schools of this state. The competency-based structure was established for the students so that their complex and confusing world takes on order and their learning tasks become more relevant and readily attained.

Instructional Units

Instructional units are based on each topic in levels I, II, and III of the Electricity/Electronics Curriculum series. Approximately 60 instructional units or packets were created for use by teachers and students. Each unit contains the following:

1. Goals and objectives
2. Lecture outline
3. Pretest and post-test (keyed)
4. Instructor's references
5. Suggested methodology
6. Demonstrations and activities
7. Student handouts—informational
8. Vocabulary enrichment list
9. Student work sheets
10. Related instructional activities and graphical illustrations

Level II Instructional Units

The instructional units for Level II are designed for use by the electricity/electronics instructor in planning, organizing, and presenting course materials. The authors of the units have attempted to provide the instructor with the tools needed to motivate and guide the student through the units. They also have tried to present the material in an interesting manner, with special emphasis on the following:

1. Marketing the subject matter
2. Innovative assignments
3. Eye appeal
4. Constant reinforcement
5. Educational games
6. Activities
7. Immediate unit evaluation
8. State of the art subject matter
9. Diversity in teaching methodology

Scope

The instructional units are generally divided into two parts, as follows:

The first part of the unit is structured to give the instructor a lesson plan overview of the unit and includes the following:

1. Title of unit
2. Time allocated
3. Unit goal
4. Unit objectives
5. Evaluation
6. Instructor's references
7. Overview (unit)
8. Suggested presentation hints/methodology
9. Supplemental activities and demonstrations
10. Instructional module contents

All of the suggestions in this part of the unit were designed to enhance the unit presentation and provide the most effective learning environment. The contents of each unit have been carefully prepared and scrutinized to provide a good technical foundation for the student.

The second part contains the packet of material to be used in the classroom. When appropriate, each unit includes the following:

1. Lecture outline/transparency master
2. Pretest and post-test (keyed)
3. Vocabulary enrichment activities
4. Student informational handouts
5. Related activities
6. Answer key

The instructional units have been constructed and packaged so that the deletion of certain materials or the addition of pertinent information can be accomplished with a minimum of difficulty. Individual courses and instructors are not the same; hence, provision for flexibility is necessary to achieve a curriculum that is compatible with the instructor.

In the event a training program requires a radical change in the content of material presented within a unit, the instructor may easily cut, insert, and paste masters to achieve the desired results, which are tailored to the instructor's specific needs.

Support Systems

No amount of planning or preparation can guarantee success in the classroom, because learning is such an intangible quality; yet, the lack of these ingredients in any program immediately guarantees dismal educational results. The most indispensable support system within the educational process is the teacher, who must have the expertise and enthusiasm to propel students into the world of learning.

The instructor must also possess the drive and ambition to improve and update the program continuously, especially in the electricity/electronics field, because of dramatic technological innovations.

The classroom should contain the necessary furniture to allow the course to be taught in a satisfactory manner. Good lighting is absolutely essential for the activities that occur. Power outlets are of paramount concern for obvious reasons, and they should be in convenient locations throughout the room. Tables, benches, and/or desks should contain locks to ensure inventory control, and storage facilities for projects, equipment, parts, and so on must be readily available. Chalkboards and bulletin boards should be mounted for easy access within the classroom.

The field of electricity/electronics seems to be a natural interest area to many students, and the laboratory portion can be used as the vehicle to generate enthusiasm. Whether instructors use individual experiments, project construction, training systems, or a combination approach in their laboratory is not critical; what is vital is that their selection reflects the goals and objectives that they want to attain within the course.

An individual school may have the best physical facility, equipment, instructional materials, and administration, but in the final analysis it is the teacher who must promote, coordinate, and maintain the program.

Unit 1

Orientation

Title of Unit: Orientation

Time Allocated: Two days

Unit Goal

To provide the student with an awareness of course goals, objectives, and basic requirements

Unit Objectives

The student will be able to do the following:

1. Give examples of the technical nature of modern society and the need for technical instruction in electricity/electronics.
2. Explain basic course requirements and the system of student evaluation.
3. Demonstrate an awareness of the general course objectives and verify the significance of each within this educational program.

Evaluation

The student will demonstrate his or her competence in the unit objectives on the basis of performance criteria established by the individual instructors. The criteria may include a combination of oral and written test procedures.

Instructor's Reference

Bohn, Ralph C., and G. Harold Silvius. *Planning and Organizing Instruction.* Bloomington, Ill.: McKnight Publishing Company, 1976.

Overview

This unit should be used by the instructor to introduce the course goals and objectives to the students. The overall significance of each goal and objective should be highlighted in a brief discussion. The unit should not be an instructor/student exercise in reading.

Basic school or classroom rules and regulations or operating procedures require attention early, and they should be presented to the students at this time. In addition, the instructor should emphasize specific course requirements and the method for student evaluation. Time should be allocated for extensive descriptions, if needed.

Suggested Presentation Hints/Methodology

Use this unit as a basic guideline for presenting the curriculum; however, note the following:

1. This unit offers the instructor an unusual opportunity to learn about important qualities each student possesses. The student questionnaire, for example, can provide a wealth of information. Read it carefully upon completion, and file all student forms by class period in one notebook for a handy reference.
2. The handout labeled "Student Performance Record" can be used for several purposes. First, it can be placed at the front of each student's notebook as a title page. It can also be used as a temporary table of contents for specific course content and/or subject-matter chronology.
3. When introducing the Information Handout "Electricity/Electronics," each student should read out loud a small portion, which will reveal those students who might need special help in reading.
4. The instructor should remember that the detailed rules for conduct and procedures are located in the safety unit and will be taught at a later time. This unit is concerned only with basic classroom conduct and procedures.

Supplemental Activities and Demonstrations

The following supplemental activities and demonstrations are suggested for use in presenting the curriculum:

1. Initial room impressions are important. If possible, have the bulletin boards adequately displayed, materials stored properly, safety signs posted, and so forth. Such things as shop appearance develop student attitudes that will affect their craftsmanship or performance.
2. During the first week of school, many students can become disenchanted with the paper shuffling. Try to demonstrate a technical device that will catch their imagination. If a strobe light, color organ, or even a microcomputer is available, use it to generate enthusiasm about the program.

Instructional Unit Contents

1. Lecture Outline (overhead)
2. Informational Handout (Course Goals and Objectives)
3. Informational Handout (Electricity/Electronics Area Description)
4. Informational Handout (Student Questionnaire)
5. Informational Handout (Student Performance Record)
6. Informational Handout (Student Evaluation System)
7. Student Answer Sheet

Unit 1

Orientation

(Lecture Outline)

A. Course Goals and Objectives

B. Rules of Conduct and Procedures

C. Course Requirements

Informational Handout

Course Goals and Objectives

This electricity/electronics program is designed to make sure that all individuals have entry-level skills when they enter the world of work or continue their education.

Some general objectives that will be accomplished with the successful completion of this course are the following:

1. An appreciation of the influence that electricity/electronics has on our lives
2. The ability to select, care for, and use electronic products, equipment, and tools
3. An awareness of safe habits and attitudes regarding materials, tools, and equipment
4. Exploration of leisure-time activities within this field
5. An appreciation of design, construction techniques, and craftsmanship
6. An understanding of the occupational families in the electricity/electronics field
7. The ability to solve problems by using sound judgments based on knowledge and experience
8. An awareness of energy conservation and its significance
9. An understanding of consumer products and their technical operation and application
10. An understanding of basic technical skills that apply to a range of jobs in electricity/electronics
11. The recognition of specific training essential for employment in a job area

Electricity/Electronics

Our grandparents would never recognize the world in which we live or many of the gadgets which are so common to us. Hundreds of electronic wonders that we readily accept in our society have become familiar objects only through the development of a new industry called electronics. This industry is now one of the largest in the United States, and a major portion of its research and production plants are located in California.

The present technology and consumer demands offer a special opportunity to students who want occupations which are interesting, challenging, and rewarding, and in which the chances for advancement are unlimited. The electronics field is one in which continuous research is always producing new products to be tested and marketed. The number of persons employed in this industry will increase at a steady rate, according to statistics developed by the State of California.

The student in electricity/electronics studies basic electrical theory, laboratory techniques, use of test instruments, care and use of hand tools, shop safety, circuits, and construction or project building. The skills which one can develop may be applied to areas of communication, transportation, computers, research and development, and so forth. If the student is deeply interested in his or her studies, has abilities, and is willing to study and learn, he or she can progress to an entry-level occupation or continue further technical training.

Basically, the electronics field is a combination of the study of mathematics and physical science, and its principles can be understood by the individual who is willing to work hard.

Informational Handout

Student Questionnaire

1. Name ______________________ Phone ____________
   Last First Middle
2. Address ______________________ Grade in school ____________
3. Age ________ Birth date ______________
   Month Day Year
4. Father's or guardian's name ______________________
   Last First Middle
5. Occupation ______________________
6. Mother's or guardian's name ______________________
   Last First Middle
7. Occupation ______________________
8. What are your hobbies? ______________________
   ____
9. Do you have a job? ______ What? ______________________
10. What occupation would you like to follow? ______________________
11. What type of education do you think is required for this occupation? ______________________
    ____
12. Previous shop courses

12. Previous shop courses	School	Grade level	Letter grade
A. General shop			
B. Drafting			
C. Woodwork			
D. Auto shop			
E. Metal shop			
F. Electricity			

13. List machines you have used in school or at home ______________________
    ____
    ____
    ____

14. List hand tools you have used in school or at home ____________________

____

____

____

15. Why are you enrolled in this class? ____________________

____

16. Whom to contact in case of an accident ____________________

Address ____________________ Phone ____________________

17. School activities (athletic teams, clubs, and so on) ____________________

____

18. School attended last year ____________________

19. List classes taken last year and letter grade for last semester.

	Class	Teacher	Grade
1.			
2.			
3.			
4.			
5.			
6.			

20. Class schedule this year.

Period	Class	Teacher	Room
1.			
2.			
3.			
4.			
5.			
6.			

21. Counselor ____________________

22. Write a brief autobiography. Include place of birth, schools attended, interests, goals, and so forth.

Student Performance Record

(Place this sheet in the front of your notebook as a title page.)

Name of student ______________________________
Last First Middle

UNIT		Unsatisfactory	Satisfactory	Excellent
1. Orientation	1.			
2. Introduction to Electricity	2.			
3. Safety	3.			
4. History of Electricity	4.			
5. Basic Electrical Skills	5.			
6. Magnetism	6.			
7. The Nature of Electricity	7.			
8. Methods of Producing Electricity	8.			
9. Electrical Flow Through Conductors, Insulators, and Semiconductors	9.			
10. Electrical Units of Measurement	10.			
11. Electrical Terms and Symbols	11.			
12. Components, Switches, and Circuits	12.			
13. Resistance and Resistors	13.			
14. Electric Lamps and Heating Devices	14.			
15. Electromagnetism	15.			
16. AC and DC Electricity	16.			
17. Motors and Generators	17.			
18. Low-Voltage Signal Devices	18.			
19. Circuit Protection Devices	19.			
20. House Wiring	20.			
21. Basic Electronics Mathematics	21.			
22. Communication Systems	22.			
23. Occupations in Electricity/Electronics	23.			
24. Opportunities in Electricity/Electronics	24.			

Rating

Name ______________________

Date ______________________

Period ______________________

Information Handout

Student Evaluation System

Students are graded as follows each quarter:

Citizenship: ______ percent

The citizenship grade is determined by attitude, cooperation, work habits, clean-up, oral participation, and attendance.

This grade may be lowered because of the following:

1. Unexcused absences
2. Unexcused tardies
3. Improper attitude or behavior
4. Shop rule violations

Laboratory and Homework: ______ percent

The laboratory/homework grade is based on the quality and quantity of the work completed at the end of each quarter.

This grade may be lowered because of the following:

1. Quantity and quality below ability
2. Inconsistent work or progress
3. Required laboratory experiments, projects, or homework not completed
4. Failure to observe safety regulations

Tests: ______ percent

This grade is determined by averaging the scores on quizzes, tests, and final examinations.

Notebook: ______ percent

The students' notebooks will be collected and graded periodically. Notes will be neat, clear, and in proper sequence. They will contain all materials and assignments completed by students and those handed out by the instructor.

Final Grade: ______

The final grade is determined by a collection of grades in the following areas:

1. Citizenship
2. Laboratory and homework
3. Tests
4. Notebook

Unit ____________

Score ____________

Grade ____________

Name ______________________________

Date ______________________________

Period ______________________________

Student Answer Sheet

	T	F		
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Unit 2

Introduction to Electricity

Title of Unit: Introduction to Electricity

Time Allocated: Three days (Units 1 and 2 require one week.)

Unit Goal

To help the student develop those competencies needed to evaluate the basic characteristics of electricity and to comprehend the dramatic role that electricity plays in our technical society

Unit Objectives

The student will be able to do the following:

1. Describe electricity in general terms and identify several major applications.
2. Define the terms *static* and/or *dynamic* electricity and indicate an appropriate example of each type.
3. Explain and/or justify the need for mastering fundamental theories related to the electricity/electronics field and verify the importance of this field to modern society.

Evaluation

The student will demonstrate his or her competence in the unit objectives on the basis of performance criteria established by the individual instructors. The criteria may include a combination of oral and written testing procedures.

Instructor's References

Loper, Orla, et al. *Introduction to Electricity and Electronics.* Albany, N.Y.: Delmar Publishers, 1979, Chapter 1.

Marcus, A., and W. Marcus. *Basic Electricity* (Fourth edition). Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1973, chapters 1 and 2.

Overview

The purpose of this unit is to provide an introduction to electricity/electronics instruction. The main objective, however, is to make the student aware of the nature, character, magnitude, and application of electricity.

The unit lesson should help the student understand that electricity is still a mystery, although society uses it in many ways.

A technical presentation should be given to explain the specific principles of static and dynamic electricity.

Unit 2 should conclude with a review of the importance of electricity and the reasons for its expanding influence and vast market of job opportunities.

Suggested Presentation Hints/Methodology

Use this unit as a basic guideline for presenting the curriculum; however, note the following:

1. This lesson should stress that static electricity is largely a nuisance, a disturber, and a potential danger in some instances. A frank discussion about lightning and how one can avoid being harmed by it should be helpful to the student.
2. Some students are reluctant to admit that they are confused by lightning. Students should understand that in this class there is no penalty for admitting that they are technically bewildered.
3. When the basic difference between static and dynamic electricity is being explained, static charges should be equated to electrical charges at rest, and dynamic electricity should be compared to electrical charges in motion to accomplish a specific purpose.
4. Students should realize as they begin their studies in this field that technical reading requires a slower pace because of the illustrations, schematics, and other graphics that must be digested. Recommend to students that they concentrate on comprehension rather than reading speed.

Supplemental Activities and Demonstrations

The following supplemental demonstrations are suggested for use in presenting the curriculum:

1. Obtain a static machine or Tesla coil and operate it in a manner to show dramatically the effects of static electricity. Check with the science department at the school for possible support materials.
2. Suspend a charged balloon from a stand; then place near the balloon a rubber rod that has been

rubbed with cat's fur or flannel. Observe the reaction and discuss it with your class. Repeat this demonstration, using a glass rod rubbed with silk.

3. With the class, itemize on the chalkboard all the uses of electricity. Have the students discuss the significance of each of the items to their daily lives and the world around them.

Instructional Unit Contents

1. Lecture Outline (overhead)
2. Technical Glossary
3. Work Sheet—The Importance of Electrical Devices
4. Activity
5. Answer Key for Unit 2

Unit 2

Introduction to Electricity

(Lecture Outline)

A. Why Study Electricity?
  1. Importance
  2. Applications
  3. Job opportunities

B. What Is Electricity?
  1. Kinds
    a. Static
    b. Dynamic
      (1) Electron flow
      (2) Direct current
      (3) Alternating current

Technical Glossary

Alternating current—A flow of electrons moving first in one direction through a circuit, stopping, then flowing in the opposite direction. Alternating current can be thought of as a back and forth movement of electrons.

Direct current—A flow of electrons moving in one direction (from negative to positive) through a circuit.

Dynamic electricity—A usable flow or movement of electrical charges. Dynamic electricity provides a continuous flow of electrons which can be used to do work.

Electric charge—A collection of positive or negative particles on an object. A material having many negative particles collected on it is said to have a negative charge. Many positive particles on a material provide a positive charge.

Electricity—A form of energy generated by friction, induction, or chemical reaction which is based on the movement of free electrons.

Electron flow—The orderly movement of electrons through a wire, electrical device, or circuit.

Electronics—The study of electrical action and the development of devices and circuits that use and control electricity.

Elektron—The Greek word for amber (a brownish-yellow fossil resin) which later evolved into the words *electrics* and *electricity*.

Static electricity—A collection of electrical charges at rest. Static charges are basically an unusable source of electricity; yet, they can be very dangerous in the form of lightning.

Score ________

Grade ________

Name ______________________

Date ______________________

Period ______________________

Work Sheet

The Importance of Electrical Devices

The world would be very different without electrical and electronic devices. At home, television sets, radios, electric stoves, telephones, and the like are important to our daily lives.

For this assignment, list ten electrical devices that are essential for our daily existence. Next, list ten such devices that may be important but that we could live without.

Necessary Devices	*Important But Not Necessary Devices*
1. ______________________	1. ______________________
2. ______________________	2. ______________________
3. ______________________	3. ______________________
4. ______________________	4. ______________________
5. ______________________	5. ______________________
6. ______________________	6. ______________________
7. ______________________	7. ______________________
8. ______________________	8. ______________________
9. ______________________	9. ______________________
10. ______________________	10. ______________________

Did you find that completing these lists was more difficult than you imagined? Some electrical devices can be both essential and luxury items, depending on their specific uses. In either case, our lives are greatly influenced by the many devices that are created through electrical technology.

TECHNOLOGY: From two Greek words:

1. *Techne* = skill
2. *logos* = word/account

Technology, then, means a description of a skill or an applied science, such as electrical technology.

Score ________ Name ____________________

Grade ________ Date ____________________

Period ____________________

Work Sheet

Activity

In your own words, write answers to the following questions. Be neat and use complete sentences when possible.

1. List five electrical machines or appliances that have recently been invented. Write your answers in the spaces provided.

   1. ______ 2. ______ 3. ______ 4. ______ 5. ______

2. Describe two ways or methods of producing a charge of static electricity.

3. What is the main difference between static electricity and dynamic electricity?

4. What great American (1706–1790) proved that lightning and electricity were the same?

5. Locate in a standard dictionary the term *electricity* and copy its definition in the space provided below.

   ____

   ____

   ____

Answer Key
for Unit 2

The Importance of Electrical Devices

(Answers will vary.)

Activity

1. (Answers will vary.)
2. Rub a glass rod with silk, move a comb through your hair, rub a rubber rod with cat fur, scuff your feet across a wool rug, and so forth.
3. Static electricity is a high-voltage charge with no electron movement and cannot be controlled. Dynamic electricity has electron movement and can be controlled to produce work.
4. Benjamin Franklin
5. (Answers will vary.)

Unit 3

Safety

Title of Unit: Safety

Time Allocated: One week

Unit Goal

To teach the student to be safety conscious, whether in the classroom, on the job, or at home

Unit Objectives

The student will be able to do the following:

1. Identify the three classes or categories of fires and indicate the proper method for extinguishing each.
2. Distinguish between common safe laboratory practices and hazardous conditions and pass a safety test with 100 percent accuracy.
3. Explain and apply the proper safety and first aid procedures when dealing with an electrical hazard or a serious shock.

Evaluation

The student will demonstrate his or her competence in the unit objectives on the basis of performance criteria established by the individual instructors. The criteria may include a combination of written or oral testing procedures.

Instructor's References

Industrial Education Safety Guide. Sacramento: California State Department of Education, 1978.

Making Safety Work. Prepared by the National Safety Council. New York: McGraw-Hill Book Co., 1976.

Overview

The unit should be introduced as a necessary and meaningful resource for all activities. To place safety in the proper perspective in the student's mind, stress that safety instruction should begin early in childhood and continue throughout life. The idea that accidents or electrical shock is unavoidable in this kind of class must be discouraged.

The central safety theme of this unit is emphasized in the discussion of rules which have been established to assist students in remembering the fundamentals of preventing accidents.

The unit also deals with the nature of electrical shock and the first aid procedures to use if necessary.

The unit concludes with a brief description of fire prevention and fire classifications. The student will also learn about the use of proper extinguishing techniques, which are dictated by the type of fire encountered.

Suggested Presentation Hints/Methodology

Use this unit as a basic guideline for presenting the curriculum; however, note the following:

1. This unit is often used to introduce both school fire drills and civil defense drills. Try to impress students during these kinds of activities with the idea that disaster preparation is the only way to save lives.
2. One of the objectives of this unit states that a safety examination must be passed with 100 percent accuracy; however, this may be virtually impossible for some students. Allow these few students the opportunity to retake the test after a study session, but do not advertise the make-up test at the beginning of the safety lesson. Certain disadvantaged students often have a very difficult time in comprehending the vast amount of written material handed out; hence, they score lower on the test than do other students. A "buddy" study system should help them in achieving a passing score.
3. Any discussion about dangerous levels of electrical current and their effect on the human body should be easily understood by those students who are not familiar with electrical terms and units of measurement.

Supplemental Activities and Demonstrations

The following supplemental activities and demonstrations are suggested for use in presenting the curriculum:

1. Obtain and show a good safety film from a reliable film source, local industry, National

Safety Council, or any other company and/or institution which offers such a service.

2. Demonstrate the actual procedures used to activate the fire extinguisher. A blast delivered by the instructor from a chemical extinguisher while the instructor is explaining operating techniques can stimulate a class instantaneously.
3. Invite a medical guest speaker to deliver a simple first-aid presentation to the class. Prior to the class lesson, explain to the guest specific areas of concentration that will help the overall safety program.

Instructional Unit Contents

1. Unit Outline (overhead)
2. Pretest and Post-Test (keyed)
3. Technical Glossary
4. Work Sheet (vocabulary)—Spelling Puzzle
5. Activity
6. Informational Handout (Shop Conduct and Procedure Rules)
7. Informational Handout (Classification of Fires and Extinguishing Techniques)
8. Informational Handout (Laboratory Safety Procedures)
9. Informational Handout (Electrical Shock)
10. Answer Key for Unit 3

Unit 3

Safety

(Lecture Outline)

A. Safety—Philosophy and Attitude

B. Electrical Shock

C. Laboratory Conduct and Procedures

D. Safety Rules

E. First-aid Procedures

F. Fire Safety

G. Civil Defense Drills

Test number ________

Examination for Unit 3

Safety

Write your answers to the questions on the answer sheet. Fill in the box that corresponds to the correct answer to the question. Each question has only one correct answer.

1. Horseplay, running, and throwing objects are dangerous practices in the shop and are forbidden:

   1. When the teacher is looking
   2. Only when students are working
   3. At all times
   4. Occasionally

2. When using machines or hand tools:

   1. Give the job all your attention.
   2. Stand up straight.
   3. Watch your classmates.
   4. Watch the clock.

3. The floor, aisles, and passageways should be kept clear of stock, tools, and materials. Objects on the floor:

   1. May be left there if the operator of the machine is in a hurry
   2. May cause someone to slip or trip into a moving machine
   3. May be ignored
   4. Are unsightly

4. Students must not talk to or distract a person operating a machine because:

   1. The operator is likely to be injured.
   2. Conversation slows down the flow of work.
   3. The operator is likely to make a mistake.
   4. Conversation is annoying to the operator.

5. Report to the teacher any:

   1. Damaged tools and equipment
   2. Missing guards
   3. Equipment that does not work properly
   4. All of the above

6. Never operate shop equipment when the teacher is:

   1. Out of the shop
   2. In the shop
   3. Both 1 and 2
   4. None of the above

7. Most tools are designed for a specific use or purpose. Improper use of tools can result in:

   1. Damage to the student's project
   2. Breakage of tools
   3. Injury to the student
   4. Damage to the bench tops

8. Long hair is dangerous around shop equipment and must be:

   1. Tied up and back
   2. Burned off
   3. Pulled out
   4. None of the above

9. Loose clothing must be securely fastened or removed, and long loose sleeves must be rolled up above the elbows:

   1. Before operating any machine
   2. After operating any machine
   3. During the operation of a machine
   4. Only when you are assisting the teacher

10. All accidents and injuries, no matter how slight, must be:

    1. Ignored
    2. Reported to the principal's secretary immediately
    3. Reported to the teacher immediately
    4. Reported to the shop supervisor immediately

11. Caution other students when you observe a violation of shop:

    1. Traffic rules
    2. Good manners
    3. Safety rules
    4. None of the above

12. Only the operator and ______________ are permitted within the working area around a machine.

    1. One other student
    2. The teacher
    3. A helper
    4. All of the above

13. Gasoline, paints, kerosene, and other materials that burn or produce fumes should be used:

    1. With another student
    2. In a well ventilated area
    3. At a workbench
    4. In an enclosed area

14. Students should operate only those machines or pieces of equipment for which they have received:

    1. Instructions to operate
    2. Permission to operate
    3. Both 1 and 2
    4. None of the above

15. When touching electrical switches, plugs, or receptacles, be sure your hands are dry because:

    1. A switch will not operate properly if your hands are wet.
    2. A plug will slip from your fingers if your hands are wet.
    3. You may receive a severe shock and serious burns if your hands are wet.
    4. None of the above.

16. Acid or chemicals on the hands or face should be washed off immediately with plenty of:

    1. Water
    2. Glycerin
    3. Olive oil
    4. Vaseline

17. If you notice any broken or damaged tools, instruments, or machinery, you should:

    1. Repair the damage yourself.
    2. Be careful when using such equipment.
    3. Say nothing because you might get the blame.
    4. None of the above.

18. Screws, nuts, and other nondigestible materials are never to be placed in your:

    1. Hand
    2. Pocket
    3. Mouth
    4. All of the above

19. When in doubt about shop procedures or the use of any tool or machine, you should:

    1. Ask an advanced student for help.
    2. Proceed cautiously.
    3. Always ask your teacher.
    4. None of the above.

20. Scraps should be swept from the workbench or table with a brush or whisk broom rather than the hand because:

    1. Sharp or jagged particles may injure the hand.
    2. Less dust is stirred up.
    3. This is the easiest way to clean up.
    4. It will cause less work for the janitor.

21. Eye protection is used to:

    1. Improve vision.
    2. Prevent eyestrain.
    3. Prevent flying particles or corrosive substances from entering the eyes.
    4. None of the above.

22. When tools are carried in the hands, keep the cutting edge or sharp points directed:

    1. Toward the floor
    2. Away from the body
    3. Over the head
    4. Toward the body to protect others

23. Never direct compressed air:

    1. Toward the floor
    2. Toward the teacher
    3. Toward another student
    4. All of the above

24. Extension and power cords should always be checked and kept in good repair because:

    1. Breaks and tears in the cords are unsightly.
    2. Breaks and tears in the cords can cause serious shocks or burns.
    3. Sparks may cause wood to burn.
    4. A short may cause the machines to burn up.

25. Carbon dioxide (CO_2) fire extinguishers may be used to put out which of the following types of fires?

1. Electrical fires only
2. Wood fires only
3. Oil fires only
4. Any kind of fire

26. Water should never be used to put out what kind of fires?

1. Wood fires
2. Electrical and oil fires
3. Paper fires
4. None of the above

27. The proper procedure for fighting a fire with a fire extinguisher is to:

1. Point the nozzle at the top of the flame.
2. Point the nozzle at the middle of the flame.
3. Cover the area around the fire and keep it from spreading.
4. Point the nozzle at the source of the fire because that is where the fire is located.

28. In case of fire in the shop, you should first:

1. Run out of the shop.
2. Throw water on the fire.
3. Sound the alarm.
4. None of the above.

29. Lifting any object that is too heavy for you:

1. Is all right if you do it slowly
2. Can be done if you know the right way to lift
3. Should never be done, because it may cause strain or rupture
4. Is a good way to show off your strength

30. What should the teacher check before turning on the power?

1. Hand tools
2. Classroom
3. All special setups
4. None of the above

31. The teacher must approve:

1. All horseplay
2. All projects
3. All fighting in the shop
4. None of the above

32. Deliberately shorting an electric circuit:

1. Is permissible if the voltage is low
2. May damage the wires
3. Is an easy method to test whether the circuit is closed or open
4. May cause an explosion or do bodily harm

33. Cutting two or more "hot" wires with pliers:

1. Is a safe practice if the handles of the pliers are insulated
2. Is permissible if the wires are 18 gauge
3. May be done safely if you are standing on a wooden floor
4. None of the above

34. Shop cleanup is the responsibility of:

    1. The custodian
    2. All of the students
    3. The teacher
    4. The principal

35. When a machine makes an unusual sound, it should be:

    1. Oiled immediately
    2. Ignored
    3. Reported to the teacher
    4. Adjusted

36. The temperature of the soldering iron should be checked with:

    1. The face
    2. A hand
    3. A piece of solder
    4. The feet

37. To remove excess solder from a soldering iron tip:

    1. Wipe it with a cloth.
    2. Shake it off.
    3. Wash it off.
    4. Use cleaning fluid.

38. When changing components in an electrical circuit:

    1. Leave the plug in.
    2. Pull the plug out.
    3. Turn the circuit on its side.
    4. Turn off the power switch.

39. Make sure that hand tools are:

    1. Sharp
    2. The proper tools for the job
    3. In good condition
    4. All of the above

40. If a tool becomes defective while you are using it, you should:

    1. Hide it so that no one will know.
    2. Report the condition of the tool to the instructor.
    3. Place it back on the tool panel and say nothing.
    4. Repair the tool yourself.

41. Before using hand tools, make sure your hands are free of:

    1. Dirt
    2. Grease
    3. Oil
    4. All of the above

42. Repairs should be made on shop equipment only with:

    1. The power on
    2. The machine running
    3. The teacher's permission
    4. None of the above

43. Spilled oil or grease is dangerous. You should always:

    1. Clean it up.
    2. Leave it.
    3. Pour water on it.
    4. None of the above.

44. The motion involved in striking or cutting must be done in a direction:

    1. Towards you
    2. Away from you
    3. Towards other students
    4. All of the above

45. A project is still dangerous even after the power switch is turned off because:

    1. It may still be plugged in.
    2. Some of the components may be hot.
    3. The capacitors can store a charge which can shock you.
    4. All of the above

46. Never use a file:

    1. Without a handle
    2. As a pry bar
    3. As a hammer
    4. All of the above

47. Pass tools to classmates:

    1. With the handles first
    2. With the points first
    3. By throwing them
    4. None of the above

48. Before starting a machine, you must:

    1. Check all adjustments.
    2. Make sure all guards work.
    3. Remove all tools and rags.
    4. All of the above.

49. Before leaving a machine, you must make sure:

    1. The guards are off.
    2. The power is off.
    3. The machine has come to a complete stop.
    4. Both 2 and 3.

50. I did as follows on this test:

    1. Well
    2. Poorly
    3. All right
    4. Terribly

Technical Glossary

Accident—An unplanned or unexpected occurrence, usually resulting in injury. The most common shop accidents can be prevented by observing safety rules, working carefully, and using common sense.

Artificial respiration—A life saving procedure used to revive a person who has stopped breathing. Artificial respiration may be required as a result of electrical shock, drowning, strangling, and so forth.

Cardiac arrest—A loss of heartbeat caused by electrical shock or high blood pressure. Closed cardiac massage is the recommended first aid procedure.

Electric shock—The flow of an electric current through the body. Shock can cause such physical effects as muscle twitching or paralysis, burns, interruption of breathing, unconsciousness, ventricular fibrillation, cardiac arrest, or death.

Fire—A combustion process characterized by heat, flame, and light. The three general classes of fire are (1) Class A fires, which involve wood, paper, rubbish, and fabrics; (2) Class B fires, which involve oil, grease, gasoline, paints, and solvents; and (3) Class C fires, which involve insulation and other combustible materials in electrical and electronic equipment.

Fire extinguisher—A portable, self-contained device that holds a liquid or chemical which can be sprayed on a fire to extinguish it.

First aid—Emergency treatment for injury or sudden illness; generally administered before regular medical care is available.

Flammable—A designation for types of materials which are easily ignited or set on fire. Other designations may be used to identify these materials, such as combustible or inflammable.

Grounding—A safety precaution which calls for placing the metal housing or case of a device at ground potential to prevent possible operator shock. The most common configuration is a third wire that is added to the power cord. This wire is connected between the case and earth ground, allowing an alternative path for current flow. Thus, if the metal housing of a device becomes electrically "hot," current will flow through the grounding wire to the earth instead of through the operator's body to earth.

Hand tools—This term refers to a wide variety of tools which require physical manipulation or primarily the use of the arms and hand muscles for their operation and use. Examples of typical hand tools would be screwdrivers, wrenches, soldering irons, pliers, and so forth.

Hazard—The presence of a dangerous or potentially dangerous situation.

Horseplay—The undesired, potentially hazardous activity of clowning or playing in the shop or laboratory.

Injury—Physical harm or damage to the human body.

Live circuit—An electrical circuit which is energized (power applied, switch on) and capable of producing current flow.

Machine tools—Generally, power-assisted tools used for heavy jobs which require work beyond that supplied by hand tools. Examples of machine tools include drill presses, grinders, sheet metal shears, box and pan break, and so forth.

Safety glasses—Protective eyeglasses with shatterproof lenses and side shields. Safety glasses should be worn when necessary while working in the shop. They provide invaluable protection by preventing foreign materials (pieces of wire, chips, broken glass, chemicals, and so forth) from entering or coming in contact with the eyes. Goggles and face shields can be used to provide additional eye protection while working in extremely hazardous areas.

Safety precaution—An action taken, followed, or observed to avoid a possible hazard or dangerous situation.

Safety rules—A specific list of rules designed to identify common situations and hazards that cause accidents. By observing the safety rules, one can avoid or prevent many accidents.

Ventricular fibrillation—A type of heart failure, caused by electric shock, in which the heart muscle no longer beats in a regular fashion but quivers erratically. If this condition is not corrected rapidly, death will result.

Score ________ Name ____________________

Grade ________ Date ____________________

Period ____________________

Work Sheet

Spelling Puzzle

Write the correctly spelled word in the space to the right, as shown in the example below.

A. (sampel) (sample) (sampal) A. sample

1. (flameable) (flammabel) (flammable) 1. ____________
2. (extinguisher) (exstinguisher) (estingwisher) 2. ____________
3. (axsident) (accedent) (accident) 3. ____________
4. (hasard) (hazard) (hazhard) 4. ____________
5. (safety) (safty) (saftey) 5. ____________
6. (percaution) (precausion) (precaution) 6. ____________
7. (injery) (injury) (ingery) 7. ____________
8. (sock) (shoch) (shock) 8. ____________
9. (first aid) (first aide) (firstaid) 9. ____________
10. (fibillation) (fibulation) (fibrillation) 10. ____________
11. (groundin) (grounding) (grownding) 11. ____________
12. (resperation) (resperasion) (respiration) 12. ____________
13. (machine) (mashene) (mechine) 13. ____________
14. (cercut) (sircut) (circuit) 14. ____________
15. (horesplay) (horseplay) (horspla) 15. ____________

Score ________

Grade ________

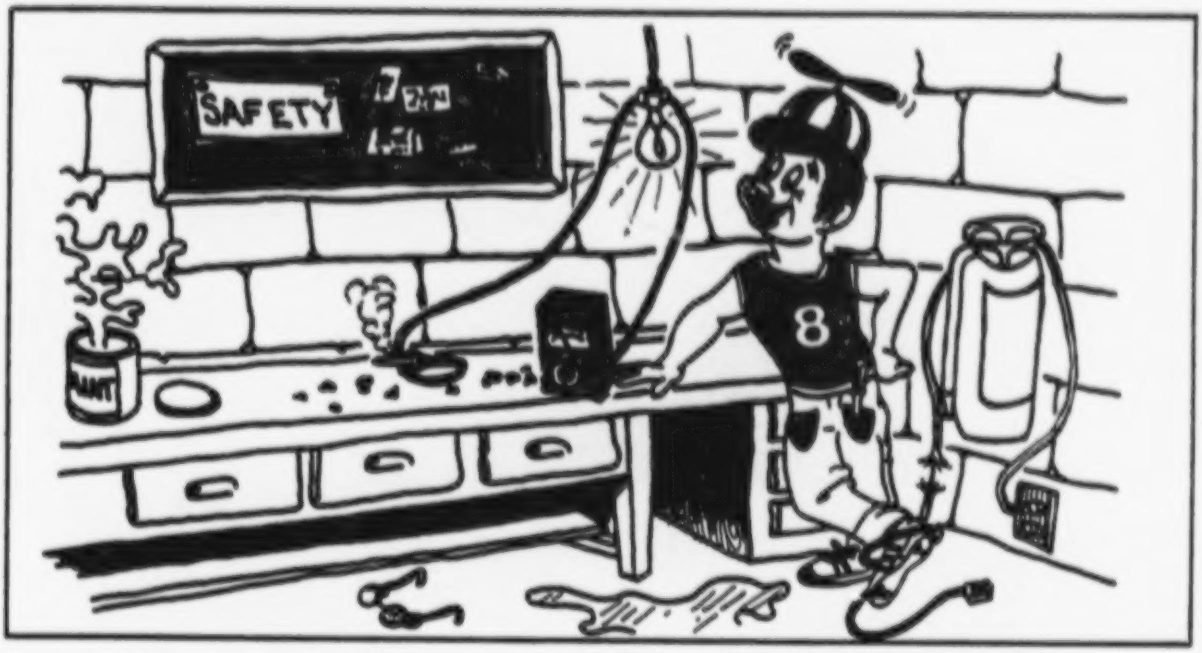
Name ____________________

Date ____________________

Period ____________________

Work Sheet

Activity



Carefully study the illustration above and locate at least ten safety violations. List your findings in the spaces below. If you are a true safety sleuth, you should be able to find 13 problems.

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________
7. ____________________
8. ____________________
9. ____________________
10. ____________________
11. ____________________
12. ____________________
13. ____________________

Informational Handout

Shop Conduct and Procedure Rules

1. Be on time and in your assigned seat before the tardy bell rings.
2. Have a notebook for this subject at your desk each day. The notebook will be collected and graded during the year.
3. Supply yourself with the necessary paper and writing tools for classroom notes.
4. Keep all handouts and notes neatly in your notebook, not scattered in your locker.
5. Do not change your assigned seat or laboratory station without consulting your teacher.
6. Do not engage in any kind of horseplay in the shop. Many painful accidents occur because of the careless and thoughtless antics of the so-called clown. Walk in the shop at all times. Loud talk and unnecessary noise will not be tolerated.
7. Do not eat, drink, or chew gum in the shop or classroom.
8. Keep your desk, laboratory station, and adjacent floor area clean.
9. Sharpen pencils before class. All trash (scratch paper, and so forth) should be kept at your desk and thrown away after class only.
10. Do not throw anything in the classroom.
11. Turn in all assignments on time. Late assignments will be graded down.
12. Use extra time constructively. Do not disturb your fellow students.
13. Attend classes regularly because (1) poor attendance will hurt your grade; and (2) missed work is difficult to make up.
14. Make up all tests or missed work.
15. Ask questions anytime on subject matter which you do not understand.
16. Consult the instructor before leaving the room during class.
17. Work safely and encourage other students to do the same by setting a good example each day.
18. Use only the machines and tools for which you have satisfactorily passed safety tests.
19. Report to the teacher any injuries or damage to yourself or equipment.
20. Refrain from any malicious activity that will cause damage to equipment and parts. You will be required to pay for any damage caused in this manner.
21. Do not remove any project or material from the shop without the instructor's approval.
22. Cooperate with the supervisor and do your fair share to keep the shop clean and attractive.
23. Return to your seat prior to class dismissal at the end of the period. Class will be dismissed only after the shop is *clean*, all tools are accounted for, and all students are quiet and in their assigned seats.

Shop Conduct and Procedure Rules

The shop conduct and procedure rules have been read and explained to me. I agree to abide by these rules. If I have any questions, I will ask the instructor.

Student's signature ____________________ Instructor's initial ____________________

Period ____________________ Date ____________________

Informational Handout

Classification of Fires and Extinguishing Techniques

Each of the three types of fire requires a special extinguishing technique. Use the chart below to distinguish the extinguishing techniques.

Class A

Fires involving combustible material such as wood, paper, or cloth are extinguished by cooling and quenching with pump-type extinguishers containing water or soda-acid. Carbon dioxide (CO_2) extinguishers may also be used.

Class B

Fires involving flammable liquids such as gasoline, kerosene, greases, thinners, and finishes should be smothered with foam and CO_2-type extinguishers.

Class C

Fires involving electrical equipment should be extinguished with a nonconducting type extinguisher such as CO_2 or dry powder. If possible, disconnect the source of electrical energy.

NOTE: Always point the fire extinguisher nozzle at the source of the fire and not at the top of the flame.

Informational Handout

Laboratory Safety Procedures

Introduction

People who work in industry know the importance of safe working habits. Safety training programs are sponsored by unions, management, public agencies, and insurance companies. Despite these efforts, accidents annually cause lost job time, painful injuries, and needless deaths.

Good safety habits are learned daily. When you begin your laboratory work in electricity, resolve to learn and practice safe working habits in the laboratory. The choice of your future safety and future laboratory work habits is up to you. Form safe habits now!

General Safety Procedures

Safe Attitudes. Laboratories are working areas for adults. Tricks, games, and horseplay should not be allowed anytime.

Safe Environment. Work areas must have proper power, ventilation, and illumination. Aisles should be open and clear. Storage areas should be kept clean and secured. The use of temporary extension cords, fans, heaters, and gas or water connections is discouraged. The work area should be neat and orderly.

First Aid Procedures. Even with good safety practices, someone may be injured. The instructor and/or the school nurse are trained in first aid procedures. Several general rules should be followed:

1. Do not panic! Determine if there is any immediate danger to the injured person. Never move an unconscious person without cause. Lay such a person flat. Keep the person warm to prevent shock. Never try to force liquids on an unconscious person. If the victim is breathing normally, keep the person still and comfortable until medical aid arrives.
2. Severe electrical shock or other types of accidents may interrupt breathing. A procedure such as artificial respiration can be used to stimulate the breathing process. Check for a swallowed tongue before applying artificial respiration. This procedure should be administered by a trained person, if possible, and continued until medical help arrives. The two common methods of artificial respiration are mouth-to-mouth and the Schaeffer method.
3. All injuries should be reported to the instructor. Even minor cuts can become infected, and the best first aid supplies, nurses, and doctors cannot help an unreported injury.

Shop Behavior and Safety Practices

1. Do not clown, scuffle, push, run, or throw objects. These practices are dangerous in any shop and are forbidden at all times.
2. Obey at all times warning signs that are posted for your protection.
3. Caution any student seen violating a safety rule.
4. Give the job at hand all of your attention, particularly when using machines or hand tools.
5. Work at a speed consistent with safety. Foolish hurry, such as rushing to complete a procedure, is dangerous.
6. Cooperate with your classmates in the shop clean-up program.
7. Do not operate machinery while the instructor is out of the room.
8. Shut off equipment that is not working properly and tell the instructor at once.
9. Report to the teacher all breakage or damage to tools, machinery, or equipment.
10. Report any dangerous situation at once to the teacher.

Eye Protection

11. Use eye protection when working in an area where hazardous conditions exist.
12. Wear face shields or goggles when extra protection is required, especially when grinding or working with caustic substances.
13. Do not use eye glasses in place of goggles or face shields.
14. Wear eye protection when compressed air is used for cleaning. Take care to direct chips, shavings, and dust away from other students. *NEVER ALLOW THE STREAM OF AIR TO COME INTO CONTACT WITH YOUR BODY.*

Clothing

15. Wear safe clothing when working in a shop. Fasten or remove loose clothing before operating any machine. Roll long sleeves above the elbows. Apron fastenings should be such that they will break if the apron becomes entangled in a machine.
16. Have the hair cut short, tied back, or tightly covered. Long, loose locks of hair can be caught easily in revolving machinery and ripped out, causing serious scalp laceration.
17. Do not wear gloves when working with power driven machinery in the laboratory.
18. Remove jewelry such as bracelets, rings, chains, and other accessories that are hazardous in shop work.
19. Do not carry sharp, pointed tools or materials in clothing. Hold sharp pointed edges down.
20. Wear protective clothing when working with chemicals. Rubber gloves should be worn when chemicals are handled or the hands are immersed in chemical solutions.
21. Wash the hands with soap and water after working with materials that might be harmful to the skin.

Housekeeping

22. Keep the work area clean and orderly. Good housekeeping is part of safety.
23. Keep the floors, aisles, and passageways clear of materials and equipment.
24. Keep tools in a safe place. Never leave them where they may cause injury. Put them in tool boxes, trays, or cases or hang them on wall panels.
25. Store material neatly and securely and in a place where persons passing will not be injured.
26. Clean up immediately any water, grease, or oil spilled on the floor.
27. Place extension cords flat on the floor so that students will not trip over them.
28. Use a brush to clean off benches and machines. Sharp or jagged particles may be found among the scraps and might cause serious injury to the hands.
29. Keep benches, cabinet drawers, and locker doors closed.
30. Keep tools and materials from projecting over the edges of benches or tables, whenever possible.

Permission

31. Do not use machines until you have been given the proper safety instruction and have received permission from the teacher. Ask for further instructions if in doubt about any operation.
32. Ask the instructor when in doubt. Do not depend on the advice of another student.
33. Pass a shop safety test to qualify to operate any power-driven machine.
34. Do not operate switches of machines and instruments unless given permission by the instructor to use them.
35. Ask the instructor to approve all projects that you plan to do.
36. Make repairs on shop equipment only when you have received permission to do so. Do not *tamper* with shop equipment.
37. Have all special setups in the laboratory approved before turning on the power.

Injury

38. Report at once all accidents and injuries, however slight, to the instructor. Infection may result from uncared for cuts and scratches.
39. When lifting heavy objects, keep the arms and back as straight as possible, bend the knees, and then lift with the powerful muscles in your legs.
40. Do not attempt to lift heavy items alone. If you have any doubt about your ability to lift an object safely, ask for help.
41. Never place screws, nuts, and other nondigestible materials in your mouth.

Fire

42. Know the location of fire extinguishers and fire exits and know fire drill procedures.
43. Do not hang objects on fire extinguishers. The area around them must be kept clear so that they may be reached without delay if a fire occurs.
44. Do not spill flammable liquids.
45. Place oily or paint-filled rags in a covered metal container.
46. Use toxic chemicals, kerosene, paints, thinners, and other finish or cleaning materials in a well-ventilated room. They should never be used near an open flame.
47. Never use water to put out an electrical or oil fire, because it will cause the fire to spread.
48. In case of fire in the shop, sound the fire alarm, turn off all gas and electricity, and put the fire out if you can do so safely; otherwise, remove yourself to a safe place.

Hand Tools

49. Be sure your hands are as free as possible of dirt, grease, and oil when using tools.
50. Select the right tool for the job to be done. Use the proper type and size hand tool for the job.

51. When using a sharp-edged tool, be sure to point the edge away from you and others.
52. Keep the cutting edges and points of tools directed toward the floor.
53. Clamp small work on a bench or in a vise when using a hacksaw or screwdriver or when performing delicate operations.
54. Never use a chisel, punch, or hammer with a "mushroomed" head. Chips may fly off and injure someone.
55. Never use a file without a handle. Be sure that the handle is properly secured to the file.
56. Pass tools to others with the handles first.
57. Never use plastic handled screwdrivers near open flames or hot soldering irons.
58. Keep metal rules away from electrical circuits. When in doubt, use a plastic or wood rule.
59. Disconnect all portable electrical tools and equipment when they are not in use.
60. Remove the attachment plug for an electric tool or appliance from the receptacle by pulling on the plug handle instead of on the cord.
61. Do not try to cut corners by using incorrect methods. There is a right and a safe way to use all tools.

Soldering

62. Never test the heat of a soldering iron by feeling the implement with your hands. Check the heat of the iron with a piece of solder.
63. Always return the soldering iron to its proper holder when not using it.
64. Always wipe excessive molten solder off the soldering iron; never flip it off. Molten solder inflicts painful burns when it comes in contact with the skin.
65. Do not pass a soldering iron directly to another person. Place the iron on the soldering iron rest so that the other person can then pick it up by the handle.
66. Take care not to let the soldering iron burn any electrical cord or circuit wire.

Machine Tools

67. Only the operator should start and stop a machine. After the machine is turned off, she or he should stand by until it has stopped running.
68. Make all adjustments to machinery before the power is turned on.
69. Remove all wrenches and other tools from machines before turning the power on.
70. Keep machine and safety guards in proper position at all times.
71. Do not overload or force in any manner any hand-operated or power-driven machine. Use only the material or stock furnished or approved by the instructor.
72. Keep rags away from machines that are in operation.
73. Make sure that everyone is clear of machines before starting them.
74. Have the instructor check all special set-ups and new operations before turning on the machine.
75. Think about your job while operating a machine. It is dangerous to talk when using power equipment.
76. Have machines at a dead stop, power off, before cleaning, oiling, or repairing them. Always turn the power off before leaving a machine.
77. Use only electric power tools that are grounded or that have UL approved housings.

Safety Zones

78. Remember that the operator and instructor are the only persons permitted within the defined working area around any machine.
79. Do not lean on machines. Always stand clear of them.
80. Do not disturb another student while he or she is working.

Electrical Circuits and Systems

81. Consider every electrical circuit live until proven otherwise.
82. Make certain your hands are completely dry before touching electrical switches, plugs, or receptacles.
83. Remember, even 110 volts can be fatal. Approach all jobs with caution and analyze each job before you start work.
84. Know the location of emergency power switches.
85. Never allow anyone to turn the power on and off while you are working with instruments.
86. Do not cut two or more wires at the same time with pliers or other tools. This is an extremely dangerous practice and may result in damage to the circuit and tools and severe injury to you if the power is on.
87. Do not apply voltage or turn on any device until the device has been properly checked by the instructor. Electricity has no respect for ignorance.
88. Always stand a safe distance from any machine or project when it is turned on for the first time. Sparks and smoke can be dangerous.
89. Do not deliberately short any electrical circuit or generating device, because shorting may damage

the equipment, cause an explosion, or do bodily harm.

90. Always wait for components such as resistors and vacuum tubes to cool before attempting to remove them.
91. Do not work around electrical equipment if the floors are damp or wet.
92. Do not work on an electrical circuit with the power turned on.
93. Be sure equipment is in proper working order before using it. Frayed cords and plugs are major sources of accidents.
94. Ask for instructions before using any piece of electronic test equipment. One wrong connection can destroy an instrument and thus deprive you and others of its use until it is repaired. And repairs can be expensive.
95. Use proper instruments for testing circuits.
96. Disconnect the power source before replacing a fuse in any electrical equipment.
97. Avoid leaving open splices or pieces of wire sticking out when making temporary or permanent connections. Secure all wires properly. Tape or cover the connections.

Laboratory Safety Procedures

The laboratory safety procedures have been read and explained to me. I agree to abide by these rules. If I have questions, I will ask the instructor.

Student's signature ______________________ Instructor's initials __________

Period ______________________ Date __________

Informational Handout

Electrical Shock

One of the major hazards in the electronics field is electrical shock. Shock is caused by electric current passing through the body. Current flow is related to the voltage applied; therefore, the higher the voltage the more serious the shock. Do not, however, get the idea that low voltages do not cause shock, because they do if the circumstances are right.

What happens when an electric current passes through the body? A number of things may occur, depending on the circumstances and magnitude of the shock:

1. A current value of 0.001 ampere produces a shock that can be felt (mild "tingling" sensation).
2. A current value of 0.01 ampere produces a severe shock, which is painful and can cause loss of muscular control (cannot let go phenomenon).
3. A current value of 0.1 ampere produces a potentially fatal shock, which can cause death if the current lasts for a second or more.

The body is sensitive to relatively small current flows. As a comparison, a common 100 watt light bulb draws a current flow of 0.85 amperes, far higher than the 0.1 ampere of current which can cause death. Other effects of electric shock include the following:

1. Muscular paralysis
2. Burns
3. Cessation of breathing
4. Unconsciousness
5. Ventricular fibrillation
6. Cardiac arrest

All of the effects of electrical shock do not occur with every shock. As stated before, conditions vary. What happens to a person depends upon the following factors:

1. The intensity of the current
2. The frequency of the current
3. The path the current follows through the body
4. How long the current passes through the body
5. Whether the shock was expected

Keep in mind that the current flow through the body, not the amount of voltage applied, is the determining factor in the severity of a shock one might receive. The higher the current, the more dangerous the shock.

Answer Key
for Unit 3

	T	F		
	1	2	3	4
1.			■	
2.	■			
3.		■		
4.	■			
5.				■
6.	■			
7.			■	
8.	■			
9.	■			
10.			■	
11.			■	
12.		■		
13.		■		
14.			■	
15.			■	
16.	■			
17.				■
18.			■	
19.			■	
20.	■			
21.			■	
22.	■			
23.				■
24.		■		
25.				■

	T	F		
	1	2	3	4
26.		■		
27.				■
28.			■	
29.			■	
30.			■	
31.		■		
32.				■
33.				■
34.		■		
35.			■	
36.			■	
37.	■			
38.		■		
39.				■
40.		■		
41.				■
42.			■	
43.	■			
44.		■		
45.				■
46.				■
47.	■			
48.				■
49.				■
50.				

Spelling Puzzle

1. Flammable
2. Extinguisher
3. Accident
4. Hazard
5. Safety
6. Precaution
7. Injury
8. Shock
9. First aid
10. Fibrillation
11. Grounding
12. Respiration
13. Machine
14. Circuit
15. Horseplay

Activity

1. The soldering iron is lying on its cord.
2. An extension cord is wrapped around the boy's foot.
3. Some liquid is spilled on the floor.
4. The meter is ready to fall off the bench.
5. An extension cord is hanging on the fire extinguisher.
6. Safety glasses have been left on the floor and stepped on.
7. Fumes are escaping from the uncovered paint can and may ignite.
8. One of the extension cords is frayed.
9. Foreign objects are on the bench.
10. The boy is carrying a tool in his pocket.
11. The power supply for the meter and soldering iron is in an awkward place and is subject to possible overload.
12. The incandescent lamp is exposed.
13. The wall outlet is the two-terminal type rather than the desirable three-terminal type.

Unit 4

History of Electricity

Title of Unit: History of Electricity

Time Allocated: One week

Unit Goal

To impart historical knowledge of developments in the electricity/electronics field and to assess the impact of these developments

Unit Objectives

The student will be able to do the following:

1. Give the word origin of the terms *electron, electrics,* or *electricity.*
2. Identify the time period in which the most significant electrical discoveries were made and their contribution to the overall field of electricity/electronics.
3. Select five historical figures discussed in this unit and describe the specific inventions and/or theories that distinguished their lives.

Evaluation

The student will demonstrate his or her competence in the unit objectives on the basis of the performance criteria established by the individual instructors. The criteria may include a combination of written, oral, and laboratory testing procedures.

Overview

Unit 4 is a nontechnical unit of instruction; however, students will acquire many basic competencies from work assignments.

The unit should be introduced with a description of the human being's first experiences with electrical phenomena. Then briefly make reference to Thales's discovery and its relationship with the present day terminology. Explain that very few significant electrical discoveries were made for several hundred years.

The unit should continue with a chronology of developments, including historical figures, inventions, and theories. This time frame of developments should conclude with a short description of the technical discoveries made by modern society.

Suggested Presentation Hints/Methodology

Use this unit as a basic guideline for presenting the curriculum; however, note the following:

1. In addition to normal classroom activities, have the students research a specific historical figure and develop a biographical sketch of the individual's life. If available, use the school library, or if this is not practical, the students may use an encyclopedia to research their subjects.
2. When introducing this unit, give examples of static electricity, and then use the chalkboard to give a historical chronology of the important events that occurred in the field. Draw a horizontal line on the board, and then on the far left-hand side place the date 600 B.C. (Thales's discovery). For the various historical events, record the year and other significant data, so that when the presentation is concluded the student will have a calendar that presents a historical sequence of technical developments.
3. Obtain historical background materials from back issues of electronics magazines. Usually they have several pages of information and historical pictures. Brief synopses of these articles make excellent informational handouts for students.

Supplemental Activities and Demonstrations

The following supplemental activities and demonstrations are suggested for use in presenting the curriculum:

1. Check whatever audiovisual resource system is available for materials that could be coordinated with the topic of this unit. Especially be on the lookout for films about Edison, Bell, Faraday, Morse, and Ohm. Many of these historical film biographies are classics and are well worth showing.
2. Compare and contrast a simple crystal radio with a modern radio to emphasize the technological advancements that have occurred. Then, draw the schematic of a crystal radio on the

board and in general terms explain how it functions. Ask a student to build a working model, and if the work is good, mount the unit on a frame for use as a demonstrator for future classes.

3. Check with the local telephone company and find out whether it has some visual presentations on the development of the telephone.

Instructional Unit Contents

1. Unit Outline (overhead)
2. Pretest and Post-test (keyed)
3. Technical Glossary
4. Work Sheet (vocabulary)—Know Your Definitions
5. Activity
6. Informational Handout (Time Line of Electronics History)
7. Answer Key for Unit 4

Unit 4

History of Electricity

(Lecture Outline)

A. Word Origin of Electricity

B. Historical Figures and Inventors

C. Basic Chronological Development

Test number ______

Examination for Unit 4

History of Electricity

Match the name of the inventor with his or her discovery or invention; write the letter of the correct response in each numbered blank.

1. Thales of Miletus	A. $E = I \times R$	1. ______
2. Stephen Gray	B. Radar	2. ______
3. Alessandro Volta	C. Battery	3. ______
4. Michael Faraday	D. Incandescent lamp	4. ______
5. Georg Simon Ohm	E. Integrated circuit	5. ______
6. Samuel Morse	F. Static electricity	6. ______
7. Alexander Graham Bell	G. Audion tube	7. ______
8. Thomas A. Edison	H. Telegraph	8. ______
9. Heinrich Hertz	I. Transmission of electricity	9. ______
10. Guglielmo Marconi	J. Production of electromagnetic waves	10. ______
11. Lee de Forest	K. Telephone	11. ______
12. William Blair	L. Transistor	12. ______
13. John Bardeen, Walter Brattain, and William Shockley	M. Generator	13. ______
14. Jack Kilby	N. Microprocessor	14. ______
15. Ted Hoff	O. Wireless communication	15. ______

Technical Glossary

Amber—A brownish-yellow fossil resin. Thales of Miletus, Greece, found in 600 B.C. that amber took on a mysterious charge if rubbed with cloth or other materials. Today, we know this phenomenon as static electricity. Interestingly, the Greek word for amber was *elektron*, which later evolved into the words *electrics* and *electricity*.

Dynamic electricity—A usable or functional flow of electricity. Dynamic electricity provides a continuous flow of electrons which can be used to do work.

Electricity—A form of energy, generated by friction, induction, or chemical reaction, whose origin is based on the movement of free electrons.

Electrics—A term coined by William Gilbert to identify materials that behave in a manner similar to that of Thales's amber; that is, materials that develop a charge when rubbed with cloth or other materials.

Electronics—The study of electrical action and the development of devices and circuits (resistors, transistors, and so on) that use and control electricity.

Historical development—The identification of an important development or invention and its chronological relationship to other inventions.

Static electricity—A collection of electrical charges at rest. Static charges are basically an unusable source of electricity for power purposes.

Score ________

Grade ________

Name ______________________

Date ______________________

Period ______________________

Work Sheet

Know Your Definitions

In your own words, write a short definition for the following terms:

1. Electricity
2. Electron
3. Electronics
4. Amber
5. Static electricity
6. Dynamic electricity

Score ________

Grade ________

Name ____________________

Date ____________________

Period ____________________

Work Sheet

Activity

Develop a one-page biographical sketch of one of the individuals identified on the time line of electronics history. Use the format presented below to organize and simplify your work. Turn in a neat, accurate, and well-worded report.

Biographical Sketch of ____________

1. Year of birth and year of death
2. Important discoveries or inventions along with dates of discovery
3. Locations where these discoveries were made
4. A short [illegible]
5. [illegible] authors, publisher, year of publication, [illegible]

Informational Handout

Time Line of Electronics History

The Record Begins in Greece

600 B.C.—Thales, a statesman and philosopher, discovered a curious attractive force between small bits of material and a material called "elektron" (amber) that had been rubbed with cloth. Today this phenomenon is called static electricity.

About 1,000 Years Later

A.D. 426—Saint Augustine distinguished between electricity and magnetism.

About 800 Years Later

A.D. 1200—Vikings were the first to use the compass for navigation. The crude device consisted of a piece of loadstone which was placed on a small board that floated in a pail of water.

A.D. 1600—William Gilbert, physician to Queen Elizabeth, discovered other materials that possessed properties similar to those of the Thales elektron materials. He called these materials "electrics." Gilbert developed the electroscope, an instrument used for detecting an electrical charge. Gilbert's work was highlighted with the publication of the first scientific study of magnetism—"de magnete."

About
A.D. 1660—Otto Von Guericke invented the first static electricity generator, which produced static electricity by friction between a rotating sulphur ball and the body.

A.D. 1675—Sir Isaac Newton, in England, discovered electrostatic induction. The effect of static charges can be felt or transmitted over a distance.

The Eighteenth Century—The Age of Basic Discoveries

A.D. 1729—Stephen Gray distinguished between conductors and insulators. He also made the important discovery that electricity can be transmitted.

A.D. 1733—Charles DuFay showed that there are two kinds of electricity, which he called vitreous and resinous. Today, we know these as positive and negative.

A.D. 1745—E. G. von Kleist and Pieter Van Musschenbroek independently developed a device for storing electric charges—the Leyden jar. The Leyden jar was the predecessor of the modern capacitor.

A.D. 1746—Gralath built an electrometer, the first instrument for measuring electricity.

A.D. 1752—In America, Ben Franklin performed his famous kite experiment to prove electricity and lightning are similar.

A.D. 1785—Charles Coulomb, in France, proved the law of inverse squares in connection with electricity and magnetism.

A.D. 1786—Luigi Galvani noticed that frog legs contracted when touched by two connected dissimilar metals. This was the modest beginning of the electric battery.

A.D. 1799—Alessandro Volta, an Italian professor, developed the voltaic pile, the first primary battery.

The Nineteenth Century—The Golden Age of Electrical Invention and Discovery

A.D. 1820—Hans Christian Oersted (Denmark) discovered that an electric current deflects a suspended magnet.

—Andre Ampere (France) demonstrated electromagnetic reaction.

A.D. 1821—Englishman Michael Faraday caused a current-carrying conductor to rotate about a magnetic field. This discovery established a basis for the electric motor.

A.D. 1825—William Sturgeon (England) made the first electromagnet.

—Georg Simon Ohm discovered that voltage, current, and resistance have a certain predictable interrelationship. Ohm's law was presented as follows: $E = I \times R$.

A.D. 1831—Joseph Henry (United States) and Michael Faraday (England) independently discovered the phenomenon of electromagnetic induction and the generation of electricity by magnetism.

—Faraday constructed a disc dynamo, the first electromechanical generator.

—Henry discovered self-induction or inductor action.

A.D. 1837—Samuel Morse (United States) invented the first practical telegraph.

A.D. 1839—Karl Gauss (Germany) published his theory of magnetism and forces of attraction.

A.D. 1841—Arc lamps were first demonstrated in Paris.

A.D. 1847—George Boole (England) established the foundation of modern computer operation in his "mathematical logic," which is known today as Boolean algebra.

A.D. 1858—Faraday supervised the installation of dynamos used to power arc lights in English lighthouses.

A.D. 1866—Cyrus Field (United States) laid the first successful transatlantic telegraph cable.

A.D. 1873—James Maxwell (England) published his scientific paper on the theory of electromagnetic radiation. This formed the mathematical foundation for radio waves.

A.D. 1876—Alexander Graham Bell (United States) developed the first practical telephone.

A.D. 1879—Thomas A. Edison (United States) invented the carbon filament lamp, the first practical incandescent lamp.

—Ernest W. Von Siemens (Germany) successfully demonstrated a three-car electric train.

A.D. 1880—Edison installed electric street lighting in New York City.

A.D. 1883—Edison discovered the Edison effect, which formed the basis for vacuum tube discoveries.

A.D. 1886—Heinrich Hertz (Germany) verified the mathematical predictions of Maxwell by producing electromagnetic waves, and thus opened the field of practical radio.

—Edison patented the carbon microphone.

—Alternating current was used in America for a commercial lighting system.

A.D. 1888—Nikola Tesla (United States) invented the AC induction motor. A company named Westinghouse manufactured it.

A.D. 1892—General Electric Company was formed.

A.D. 1896—Guglielmo Marconi (Italy) sent radio telegraph messages over a distance of 9 miles (14.4 kilometres).

A.D. 1897—Marconi demonstrated the ship-to-shore wireless.

—Karl Ferdinand Braun (Germany) constructed the first cathode-ray oscilloscope.

A.D. 1899—Sound was first recorded on magnetic wire.

A.D. 1900—William Duddell discovered that an electric arc can be made to produce continuous oscillations. Continuous oscillations formed the basis for early spark-gap transmitters.

—Reginald Fessenden first transmitted speech by a wireless.

A.D. 1901—The first transatlantic wireless message was transmitted.

A.D. 1903—Ernest Alexanderson built the first high-frequency alternator at General Electric. The alternator produced a 100-Khz wave.

A.D. 1904—John Fleming (England) patented a two-element thermionic device, called the Fleming valve, based on the Edison effect. It was used to detect Hertzian waves and is known today as the diode tube.

The Vacuum Tube Era (1906–1947)

A.D. 1906—General Dunwoody developed the crystal detector which used Carborundum to detect signals.

—Lee de Forest (United States) added a grid to the Fleming valve, producing the audion tube, a three-element device which laid the foundation of modern electronics. The audion tube is known today as the triode tube.

A.D. 1915—The first transatlantic radio telegraphy communication was made from the United States.

A.D. 1917—George Campbell developed the first electrical wave filter, making possible communication "channels."

A.D. 1920—KDKA, Pittsburgh, the first broadcast radio station, began operation.

—Edwin Armstrong designed the superheterodyne circuit, a forerunner of modern radio receivers.

A.D. 1923—Vladimir Zworykin patented the iconoscope TV camera tube.

A.D. 1925—TV was demonstrated by John Baird in England.

A.D. 1929—Zworykin demonstrated the kinescope, the first modern picture tube.

A.D. 1930—William Blair patented the first basic radar system.

A.D. 1931—The oscilloscope was produced by Allen DuMont.

A.D. 1933—Karl Jansky discovered radio astronomy.

A.D. 1937—Varian Brothers invented the klystron tube—a high power microwave oscillator.

A.D. 1938—William Hewlett and David Packard (United States) worked to produce a diathermy machine for Stanford Hospital.

A.D. 1939—NBC demonstrated TV broadcasting using the new orthicon camera developed by RCA.

A.D. 1941—Commercial FM broadcasting began in the United States on January 1.

—Commercial TV was authorized by the FCC on July 1.

—The first military application of a newly developed radio-detection device (radar) was made on December 7 at Pearl Harbor.

A.D. 1942—Magnetic recording tape was developed.

A.D. 1944—Howard Aiken, Harvard University, developed a digital computer called the automatic-sequence-controlled calculator, which was used extensively by the U.S. Navy.

—V-beam radar was introduced by MIT's radiation laboratory. This was the first practical do-everything radar.

A.D. 1946—RCA introduced the first mass produced black and white television: model 630TS with a 10-inch (25.4-centimetre) picture tube and a sales price of $375.

—The Eniac computer was developed at the University of Pennsylvania. The digital programmable machine handled 5,000 arithmetic calculations per second, weighed 30 tons (27 240 kilograms), contained 18,000 vacuum tubes, and required 130 KW of power. By today's standard Eniac was comparable to a basic hand-held calculator.

—RCA demonstrated the first "all electronic" color TV.

A.D. 1947—Bell Laboratories demonstrated the first signal amplified by a semiconductor crystal. The work of John Bardeen, Walter Brattain, and William Shockley resulted in the germanium point-contact transistor.

The Transistor Era (1948–1959)

A.D. 1948—The transistor was born, marking the beginning of modern electronics.

A.D. 1949—The record business was shattered; the 78 RPM was out. RCA introduced the 45 RPM disc, while CBS developed the 33$^1/_3$ format.

A.D. 1951—The Univac I computer was introduced by the Remington-Rand Corporation.

A.D. 1952—RCA experimented with the first all-transistorized television set.

—Andrew Kay developed the first digital voltmeter at Non-Linear Systems Company.

A.D. 1953—H. J. Zeigler developed the beam maser—a device that could amplify microwave signals with light. This amplifier was the forerunner of the laser.

—Tektronix introduced the concept of plug-in modules for test equipment.

A.D. 1954—Bell Laboratories perfected a method of growing single-crystal silicon. This development laid the foundation for today's multibillion-dollar semiconductor industry.

—Calvin Fuller of Bell Laboratories developed the process of diffusing impurities into the surface of silicon wafers, thus paving the way for the development of the integrated circuit.

—Texas Instruments introduced the silicon transistor.

—Daryl Chapin, Calvin Fuller, and Gerald Pearson at Bell Laboratories developed the solar battery (cell).

—The first application was made of transistors to consumer products. Regency Company marketed a four-transistor radio.

A.D. 1955—Tappan introduced the microwave oven for home use.

—Mucan Corporation and Bell Laboratories developed the varacator diode, then known as the voltage-variable capacitor and used today for electronic tuning with no moving parts in TVs and radios.

A.D. 1956—Bell and Howell introduced the all-electronic movie camera.

—Bell Laboratories demonstrated the feasibility of the TV telephone.

—GE commercialized the silicon-controlled rectifier (SCR).

A.D. 1957—Russia launched Sputnik—the first human-made orbital satellite.

—Burroughs Corporation developed the first gas-discharge numerical readout tube called the "nixie."

—U. Gianola of Bell Laboratories developed the plated wire memory. At IBM, large rotating disks were used for the first time to make a random access memory capable of storing up to five million characters.

—RCA unveiled a miniaturized FM transmitter small enough to be swallowed. Today's astronauts use modern versions of these pill transmitters to send physical data back to earth.

A.D. 1958—The first integrated circuit was developed by Jack Kilby at Texas Instruments. The crude circuit contained several transistors, a few resistors, and some capacitors. Today, a similar sized IC contains up to 10,000 transistors. At about the same time, at Fairchild's Semiconductor Division, Robert Noyce developed a similar type of circuit in which all components were integrated or formed on a single chip of silicon.

—GE and Crystalonics introduced commercial field effect transistors (FET).

—Stereo phonograph records began to appear. A few radio stations begin to broadcast in stereo.

A.D. 1959—RCA introduced the nuvistor, a thimble-sized vacuum tube, which heralded the last attempts of tube manufacturers to compete against transistor devices.

The Integrated Circuit Era (1960–   )

A.D. 1960—Fairchild developed the planar process for the production of transistors and ICs. This process involved the evaporation of aluminum over the circuit to form conductors.

—Texas Instruments offered the first IC product line, called the Solid Circuit Series 1, which consisted of simple logic circuits.

—Bell Laboratories developed the epitaxial process which allowed a crystal structure to be grown on a substrate or another crystal structure. This technique became the mainstay of transistor and IC fabrication.

A.D. 1961—Laser devices were developed by Hughes, Bell Laboratories, Raytheon, and IBM.

A.D. 1962—The solid-state laser was developed at both GE and IBM research laboratories.

—Signetics introduced diode-transistor logic.

—The first light-emitting diodes (LEDs) were developed, although they were not commercially available until 1968.

—The Telstar communications satellite was launched on July 10, making possible satellite-relayed communication via telephone and television.

A.D. 1963—The first commercial minicomputer was introduced by Digital Equipment Corporation. The model PDP-5 used a 12-bit format, contained 1 k of memory, and sold for $27,000.

—Sylvania introduced the first integrated circuits using TTL logic, which was designated as Sylvania's universal high level logic.

A.D. 1964—IBM introduced the system 360 computer series, which was intended to replace all existing IBM computer series.

—Zenith produced the first consumer hearing aids to use integrated circuits.

—Texas Instruments introduced the 5400 series TTL logic series.

—Fairchild introduced one of the first linear ICs—the 702 OP amp.

—The dual in-line package (DIP) first appeared.

A.D. 1966—Andrew Bobeck announced the development of magnetic-bubble devices.

A.D. 1968—RCA introduced a new IC technology—COS/MOS.

A.D. 1969—On July 20, Apollo 11 astronauts Armstrong and Aldrin landed on the moon. The successful landing and return to earth culminated a decade of breakthroughs in electronics.

A.D. 1970—Intel developed the first dynamic MOS random access memory (RAM), a 1,025-bit device. Prior to this development, computer memories used magnetic cores or semiconductors.

—Mostek and TI showed that all the logic for a four-function calculator could be put on a single chip by using a technique known as MOS/LSI.

—Harris Semiconductor introduced the PROM, a new user-programmable memory.

—Hamilton introduced the "Pulsar," an LED display wristwatch for $2,100.

A.D. 1971—Ted Hoff spearheaded the development of the first microprocessor—the Intel 4004. Shortly thereafter the 8008 CPU chip was introduced.

—Hand-held calculators made their debut. Simple four-function units were produced by Hewlett-Packard, Sharp, and Texas Instruments. They sold for $400.

A.D. 1972—Liquid crystal displays offered a new technology for numerical displays, offering the advantage of low power consumption and high visibility in daylight conditions.

—Breakerless electronic ignition systems became available as original or add-on equipment for automobiles.

—Microma Universal introduced the first commercial liquid crystal display wristwatches for $150.

—Magnavox marketed the first Odyssey TV game units. Atari followed with Pong in 1976.

A.D. 1973—Intel upgraded the 8008 and introduced the 8080. National Semiconductor and Rockwell fielded their own microprocessor designs.

—I^2L (integrated-injection logic) emerged due to the work of IBM and Philips. This new circuit technique allowed high density, high operating speed, and low dissipation. The first I^2L products (a 4-bit microprocessor and a watch circuit) were introduced by Texas Instruments.

—Advent introduced "Video Beam" projection TV.

A.D. 1975—Home videotape recorder systems were presented by AVCO (Cartivision), Sony (Betamax), and others.

—Microprocessor-based home computers began to appear in the hobby and engineering markets. The first units were sold in kit form by companies such as MITS (Altair), Sphere, IMSAI, and Southwest Technical Products. These first machines were generally 8080 or 6800 based. The machines became financially feasible due to the cost effective production of LSI chips, which dropped the price of the original microprocessor chip from $200 to $20 each.

—Ionization and optical smoke detectors were introduced for home use.

A.D. 1976—The body scanner, an X-ray-type machine which is capable of analyzing the complete body for medical growths, tumors, bone problems, and so forth, was introduced by GE.

A.D. 1977—Forty-channel CB radio was approved by the FCC.

—A new generation of home computers emerged. These systems were preassembled, offered simplified programming techniques, and were comparatively low in cost. The Radio Shack TRS-80, Commodore PET, and Apple II were examples of this new breed.

—The world's first optical (fiber-optic) communications system to provide regular telephone service was placed in operation by General Telephone Company. This feat culminated years of work in development and experimentation with optical fibers and appropriate light sources.

A.D. 1978—New era microprocessor chips based on 16-bit words instead of the more common 8-bit word length promised to deliver ten times the performance of the industry-standard 8080 chip.

WHAT NEXT?

Answer Key
for Unit 4

	T	F		
	1	2	3	4
1.	F			
2.	I			
3.	C			
4.	M			
5.	A			
6.	H			
7.	K			
8.	D			
9.	J			
10.	O			
11.	G			
12.	B			
13.	L			
14.	E			
15.	N			
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
25.				

Know Your Definitions

1. (Answers will vary.)
2. (Answers will vary.)
3. (Answers will vary.)
4. (Answers will vary.)
5. (Answers will vary.)
6. (Answers will vary.)

Activity

(Answers will vary.)

Unit 5

Basic Electrical Skills

Title of Unit: Basic Electrical Skills

Time Allocated: Four weeks

Unit Goal

To help the student develop basic skills in the use of tools, electrical wiring, and project assembly techniques

Unit Objectives

The student will be able to do the following:

1. Describe the function, list safety precautions, and illustrate the correct use of each construction tool presented in this unit.
2. Identify and demonstrate proper soldering techniques and methods of preparing conductors for electrical use.
3. Successfully construct a wiring project and demonstrate competence in following instructions, tool use, chassis layout, soldering, assembly techniques, inspection, and testing.

Evaluation

The student will demonstrate his or her competence in the unit objectives on the basis of the performance criteria established by the individual instructors. The criteria may include a combination of written, oral, and laboratory testing procedures.

Instructor's References

Buban, Peter, and Marshall L. Schmitt. *Technical Electricity and Electronics.* New York: McGraw-Hill Book Co., 1971, units 27–31.

Duarte, S. R., and R. L. Duarte. *Electronics Assembly and Fabrication Methods.* New York: McGraw-Hill Book Co., 1973, chapters 1 and 5–10.

Villanucci, R. S., A. W. Avtgis, and W. F. Megow. *Electronic Techniques: Shop Practices and Construction.* Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1986.

Overview:

Unit 5 can be used to help the student to develop competencies that will provide a basis for future mechanical and electrical assembly tasks.

The unit should be introduced as a valuable resource in project planning and construction. The idea of constructing a project should be stressed as a necessary hands-on experience to facilitate working with devices and processes.

The central theme is to present a variety of basic electrical skills for the students to develop; however, high quality work must be emphasized by the instructor as an ongoing process at all levels of activities.

Most of the major topics in this unit can be presented in laboratory demonstrations, and the student wiring project can be used to evaluate the students' understanding.

This unit has a relatively long time allocation. For the student it focuses on a fascinating and motivating aspect of the course.

Suggested Presentation Hints/Methodology

Use this unit as a basic guideline for presenting the curriculum; however, note the following:

1. When illustrating basic hand tools and describing their functions, the instructor can use an overhead projection to show tool outline or shape. In addition, tools can be traced with color pencils to assist less able students in learning the basic differences in size, shape, and so forth.
2. When demonstrating practices encountered in assembly and fabrication, the instructor should stop and describe large-scale production techniques. Indicate and show some of the jobs which are relatively simple and require little training; then, describe more complicated jobs which require extensive preemployment training.
3. A building project for the student is definitely mandatory in this unit, but it need not be a one-to-one situation. A class assembly-line-type project can be used to teach a variety of techniques and is cheaper to implement. Divide the laboratory into three work stations: mechanical assembly, electrical assembly, and inspection/testing. Allow the students to perform only those skills associated with that work station; however, rotate the students so that they can be exposed to other competencies.

4. At this educational level it is wise when instructing students in chassis construction or other fabrication techniques to use metal templates to assist in achieving the most positive results.

Supplemental Activities and Demonstrations

The following supplemental activities and demonstrations are suggested for use in presenting the curriculum:

1. The vocabulary list presented in this unit is long and cumbersome. Spend enough time in describing each term, and, if possible, demonstrate each tool listed, emphasizing safety precautions when appropriate.
2. Discarded cardboard boxes should be used as a material resource. Lay out various component positions for the project chassis or project front panel on a sheet of graph paper; then select the best design and cut a piece of cardboard to the actual front panel dimensions. Attach all pots, switches, lamps, jacks, meters, and so on where indicated and check the overall aesthetics. If there is an error in the layout of a special problem in mounting a part, it can be worked out on a cardboard model rather than on the original chassis or cabinet. This procedure will assist students in completing a project that is not only functional but also a pleasure to view.

Instructional Unit Contents

1. Unit Outline (overhead)
2. Pretest and post-test (keyed)
3. Technical Glossary
4. Work Sheet—Tool and Hardware Identification
5. Work Sheet—Soldering, Splices, and PC Fabrication
6. Activity
7. Informational Handout (Guide to Soldering)
8. Informational Handout (General Assembly and Construction Hints)
9. Informational Handout (Electrical Connections)
10. Informational Handout (Printed Circuit Board Fabrication)
11. Informational Handout (Printed Circuit Board Fabrication—Photographic Method)
12. Project Evaluation Sheet
13. Answer Key for Unit 5

Unit 5

Basic Electrical Skills

(Lecture Outline)

A. Identification and Proper Use of Basic Hand Tools

B. Soldering
   1. Heat, flux, and solder
   2. Preparations for soldering
   3. Making of a solder joint

C. Making Simple Conductor Joints
   1. Preparation of conductors
   2. Mechanical and electrical connections
   3. Splices
   4. Solderless connectors and terminals
   5. Terminal and socket connections
   6. Printed circuit soldering

D. Insulating Conductor Joints

E. Wire Types and Gauge Determination

F. Assembly Techniques
   1. Harness assembly
   2. Component assembly
   3. Chassis hardware and assembly

G. Printed Circuit Board Fabrications

H. Proper Use of Power Tools and Stationary Equipment

Examination for Unit 5

Basic Electrical Skills

Write your answers to the questions on the answer sheet. Fill in the box that corresponds to the correct answer to the question. Each question has only one correct answer.

1. Wire strippers are used to remove the conductor from wires. (T-F)
2. A stranded wire is less flexible than a solid wire of the same gauge. (T-F)
3. Side-cutting pliers are sometimes called lineman's pliers. (T-F)
4. A hand punch or chassis punch is used to make round holes in sheet metal. (T-F)
5. The preferred solder to use in electronic project construction is 60/40 rosin-core solder. (T-F)
6. A dull-colored solder joint on a PC board is acceptable as long as enough solder is used. (T-F)
7. A wire being soldered to a lug is usually first loosely fastened to the lug to hold it in place. (T-F)
8. Conductors or traces on a printed circuit board often cross or overlap. (T-F)
9. Drilling holes in sheet metal can be a dangerous operation. (T-F)
10. A chassis forms the base on which a circuit is assembled or mounted. (T-F)
11. Diagonal-cutting pliers are designed for stripping wires. (T-F)
12. Pretinned hook-up wire is coated with a thin layer of tin to prevent the copper conductor from oxidizing. (T-F)
13. Long-nose pliers are designed primarily for holding and bending small-gauge wires. (T-F)
14. A newly soldered wire should not be moved or handled until the solder has solidified sufficiently. (T-F)
15. The process of removing unwanted copper from a printed circuit board with a chemical solution is called etching. (T-F)
16. A 24-gauge wire has a larger diameter than a No. 12 American Wire Gauge wire. (T-F)
17. Magnet wire is most often insulated with a coating of enamel or lacquer. (T-F)
18. The job of removing solder from a terminal or PC joint is done with an unsoldering tool. (T-F)
19. Sheet metal can be cut with tin snips, aviation snips, or the box and pan brake. (T-F)

20. A Phillips-head screw can be driven by either a standard blade screwdriver or a Phillips screwdriver. (T-F)

21. The process of coating a wire, terminal, or soldering iron tip with a thin layer of solder is called ______.

22. Solder used for electronic work is usually in wire form and contains one or more cores of ______.

23. The joining together (twisting) of two or more wires to form a permanent connection is called a ______

24. In the soldering of components that are sensitive to excessive heat, a tool called a ______ should be used.

25. An important step in PC fabrication is to ______ thoroughly the board to remove dirt and grease.

Technical Glossary

Adjustable wrench—An open-end-style wrench with adjustable jaw size. This type of wrench is designed with one stationary jaw and an adjustable jaw operated by a thumbscrew. The wrench can be used on nuts or bolts of many different sizes.

Assembly—The fitting together of parts, using tools and necessary equipment to form a complete unit or device.

Aviation snips—Sheet-metal-cutting shears which have a compound lever action for reducing cutting effort.

Ball-peen hammer—A general purpose metal-working hammer with one flat face for hammering and a rounded or ball head for rounding off rivets.

Box and pan brake—A heavy-duty sheet metal tool with adjustable fingers used to make inside and outside bends.

Cable ties—Small nylon belts or straps, with a self-locking buckle, used to bind or harness wires together.

Center punch—A metal punch with a sharp (60-degree) point. The center punch is used to mark the location of a hole that is to be drilled, thus eliminating drill "wandering."

Chassis—A metal box or frame upon which major components or subcircuits are mounted and wired.

Chassis punch—A sheet metal punch designed for punching round holes in sizes ranging from ½ inch to 3 inches (1.3 centimetres to 7.6 centimetres). The punch halves are drawn together with a machine screw. Chassis punches are also available in square, keyed, and half-round styles.

Component—A general term describing an electrical part or parts. For example, basic electrical parts such as resistors, capacitors, diodes, and transistors can be identified as components.

Conductor joints—A method for connecting or securing two or more wires together. A satisfactory conductor joint must be (1) mechanically secured with wires tightly twisted together; (2) electrically secured so that the connection will freely pass current; and (3) covered with an approved insulation.

Desoldering tool—A device used to remove molten solder from a wire or connection. Most desoldering tools draw the molten solder from the connection with a vacuum or suction force.

Diagonal-cutting pliers—Pliers used for cutting soft metal wire. Two popular terms used for identifying the pliers are *diagonals* and *dykes*.

Drill press—A motorized tool used for drilling or boring holes in a piece of stock. Drill bits are held securely in the chuck and fed into the work with the feed handle.

Electrical connection—A connection that will conduct electricity as efficiently as a continuous wire. A good electrical connection requires that the wires be absolutely clean and that they be twisted together to achieve good contact. Many times, solder is added to the joint to achieve a good electrical contact.

Electrical tape—A black vinyl insulating tape used to cover exposed conductor joints.

Etching—The process of chemically removing the excess copper from a circuit board. The more common etching solutions are ammonium persulfate and ferric chloride.

File—A tool used mainly to smooth the edges of sheet metal and to do small amounts of cutting, shaping, and fitting of metal parts.

Flux—A chemical used to remove oxygen during the soldering process and to clean the copper surface of slight oxidation. Flux aids in making a good solder joint. For electrical work, use only rosin flux, which is available as a paste or as a core in the solder.

Gauge—A standard method for sizing wires. Gauge sizes are given as numbers, such as 24 gauge or 24g. The lower the number, the larger the diameter of the wire.

Hacksaw—A handsaw used for cutting metal. The hacksaw cuts on the forward motion only.

Hand punch—A sheet metal hole punch used for punching small round holes up to approximately ½ inch (1.3 centimeteres) in diameter. The tool uses a collection of punch and die sets which are mounted (one size at a time) in a handle/frame unit.

Hardware—Items designed to provide physical or electrical support for projects. Physical support hardware includes items like screws, bolts, clamps, nuts, and spacers, while electrical support items include switches, lamps, sockets, fuses, and terminals.

Harness—Individual wires tied together in a neat bundle and routed through the project as a group. A harness typically has wires leaving the bundle at various locations.

Heat sink—A small metallic tool used to draw heat away from a component or connection during the soldering process.

Heat shrinkable tubing—An insulating tubing which is slipped over a connection or joint. When the tubing is heated with a heat gun, match, or soldering iron, it will shrink and form tightly around the connection.

Insulation—A material placed around a conductor, connection, or joint to prevent a short circuit or an accidental shock.

Lacing—The process of making a series of special ties with a piece of lacing cord along the length of a cable.

Long-nose pliers—Pliers used primarily for handling small objects and for bending and shaping wires. Most long-nose pliers also incorporate a cutting jaw for cutting small-gauge wires.

Magnet wire—Wire used in making coils in inductors, small transformers, relays, and so on. The wire is usually insulated with a clear coat of enamel or varnish.

Mechanical connection—The process of attaching wires to terminals, or another wire, by twisting or bending them in such a way that the connection remains secure even though it is not soldered.

Nut driver—A tool designed for rapid installation or removal of nuts. The tool resembles a socket wrench attached to a screwdriver handle.

Open-end wrench—A general purpose wrench which has an open jaw of a different size at either end of the tool.

Portable electric drill—A hand-held power tool used for boring holes in various materials. The tool uses a chuck to hold the drill bit and usually has a trigger-style switch as a control.

Printed circuit board—Consists of metal foil conductors, usually copper, bonded to a substrate or base material. The base material supports the components which are loaded into holes drilled in the board and soldered to the conducting foil. Foil traces serve as the interconnecting wires for the circuit.

Resist—A material used in printed circuit board fabrication to cover or coat the areas which are to be saved on the copper-clad board. The resist will form a pattern similar to the pattern of the completed printed circuit board traces.

Screwdriver—A tool used with a twisting motion to tighten or loosen screws. The two common tip types are slotted or standard and Phillips-head.

Side cutting pliers—Side cutting pliers or lineman's pliers are heavy duty pliers used for gripping and cutting large gauge wires.

Slip joint pliers—A common type of plier designed for holding or gripping work. The slip joint permits the jaws to be opened wider.

Solder—An alloy of tin and lead which is melted into an electrical connection to increase conductivity, improve mechanical strength, and protect against oxidation. Solder used for electrical work is generally designated as 60/40 rosin core; that is, 60 percent tin and 40 percent lead with a central core of rosin. This type of solder has a melting point of 370° F. (187.7° C), good mechanical strength, and a rapid cooling rate.

Solder joint—The process of cleaning, heating, and properly applying solder to a connection, splice, or joint.

Soldering iron—A tool with a heated tip used to transfer heat to a connection for soldering. The type of iron used for general electronic work is called a pencil iron and has a rating between 25 and 40 watts.

Solderless connector—Also designated as solderless terminals or crimp connectors, these devices do not require soldering; rather, the wire is inserted into a lug, and the lug is squeezed with a special tool to make the electrical connection.

Solid wire—A type of wire that consists of only one solid conductor, usually surrounded by insulation.

Splice—A method for connecting two or more wires. Examples are the tap splice, rat-tail splice, or Western Union splice.

Squaring shear—A piece of stationary equipment used for cutting, trimming, and squaring sheet metal. The cutting blade is operated either by a foot treadle or by a lever handle.

Stranded wire—A type of wire which consists of many strands of fine wire twisted together. The twisted conductors are then covered with an insulating material. Stranded wire is more flexible than solid-style wire of the same gauge.

Tapered hand reamer—A T-shaped tool used to enlarge slightly the size of a hole drilled in metal or sheet metal.

Tinning—The process of cleaning and coating with solder. Tinning is usually thought of in connection with preparing the heated tip of a soldering iron, but wires, terminals, printed circuit boards, and component leads are often tinned in preparation for making an electrical connection.

Tin snips—A scissorslike tool used for cutting sheet metal.

Trace—Copper foil patterns which are left on a printed circuit board. These foil traces act as the interconnecting wires between the components.

Twist-on connector—A type of insulated solderless connector used for making rat-tail joints. To use a twist-on connector, thread it onto a pair of bare conductors, which are held parallel to each other. The conductors will twist together and hold firmly.

Twist drill—A style of drill bit made of carbon steel and used for drilling holes in metals. The twist drill is used in conjunction with a drill press or portable electrical drill.

Vise—A tool used to hold work pieces while drilling, cutting, soldering, and so on. The most common style of vise is called a bench vise, although many specialty vises are available for electronics work.

Wire strippers—A common tool used to remove the insulation from a conductor or wire.

Score ________

Grade________

Name ____________________________

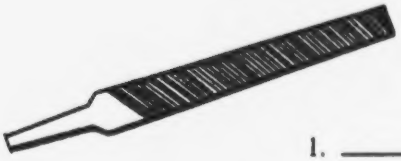
Date ____________________________

Period ____________________________

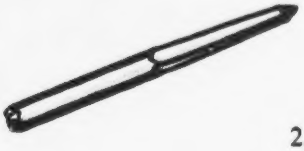
Work Sheet

Tool and Hardware Identification

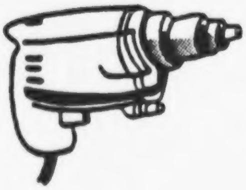
Use complete names in identifying the items shown below.



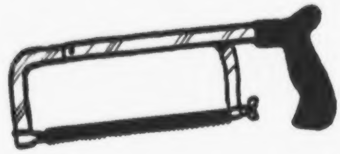
1. ____________



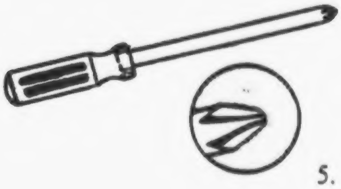
2. ____________



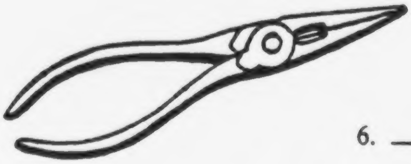
3. ____________



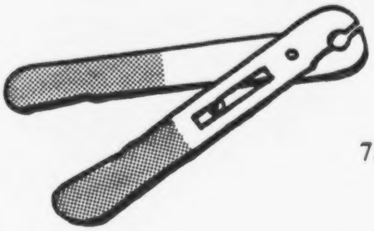
4. ____________



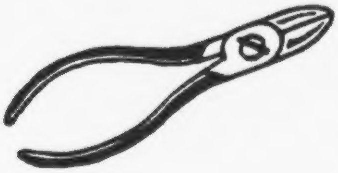
5. ____________



6. ____________



7. ____________



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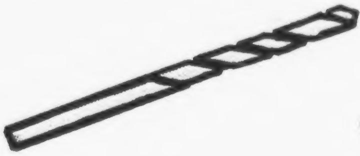

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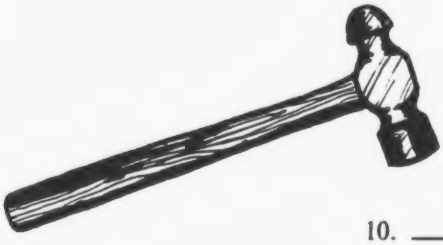

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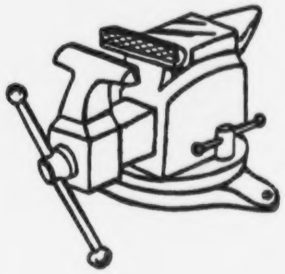

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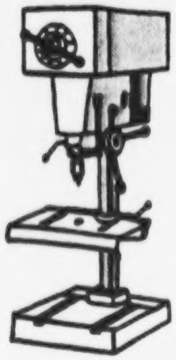

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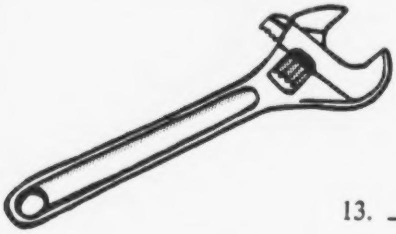

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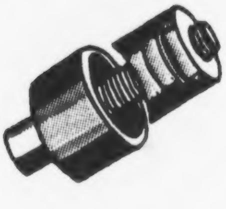

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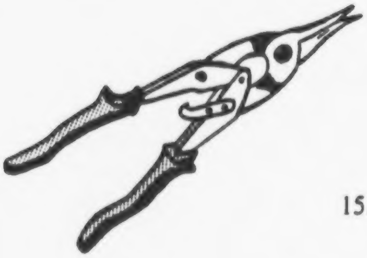

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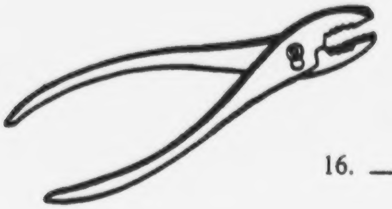

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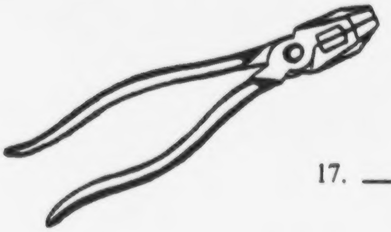

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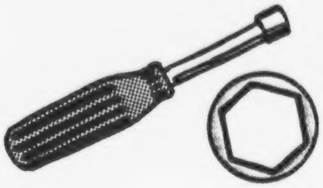

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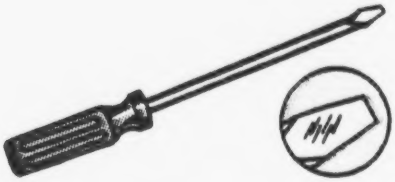

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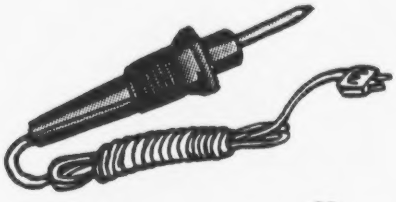

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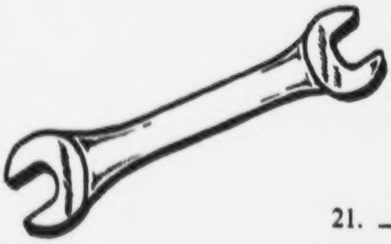

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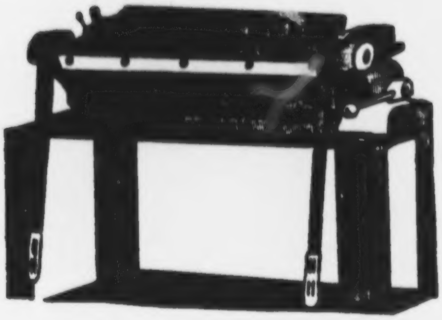

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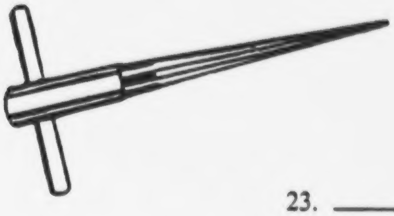

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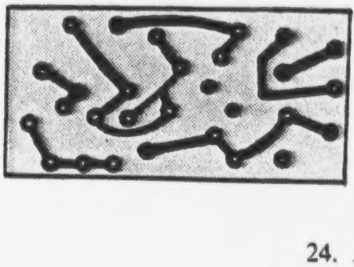

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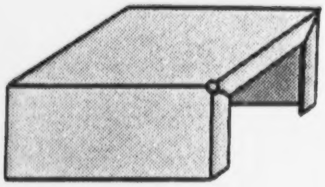

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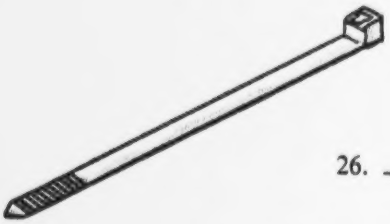

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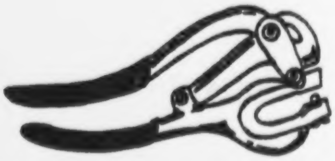

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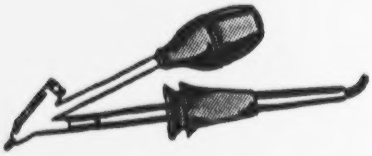

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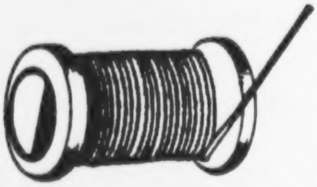

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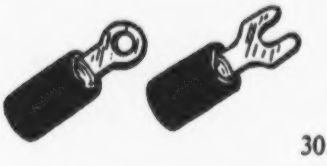

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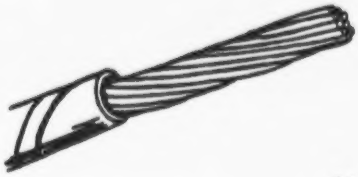

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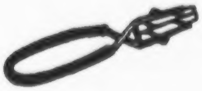

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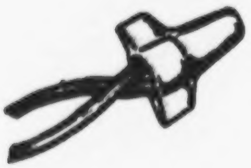

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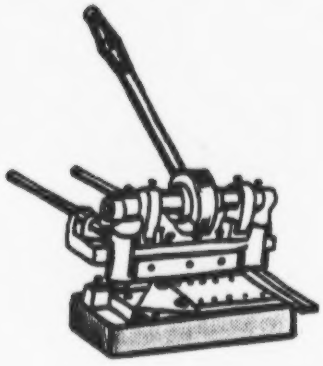


34. ____________

Score ________

Grade ________

Name ________________________

Date ________________________

Period ________________________

Work Sheet

Soldering, Splices, and PC Fabrication

1. Give three important reasons for soldering an electrical connection.

2. Make a list of the steps that should be followed in making a good solder connection. Explain each step as necessary.

3. Draw a neat sketch of the following types of wire splices:

Rat-tail Splice	Tap Splice	Western Union Splice

4. Describe the method or technique used in the laboratory for applying resist material to a PC board. Be specific.

5. Explain the procedure and precautions to be followed while etching a PC board.

Procedure	Safety precautions

Score ________

Grade ________

Name ____________________

Date ____________________

Period ____________________

Work Sheet

Activity

Purpose

The project you are about to begin has a definite purpose. As you proceed through the assembly process, you will gain important experience in chassis fabrication, hand tool usage, soldering, point-to-point wiring, and cable harnessing/layout. Keep in mind that your aim is to work carefully and produce a quality product.

Parts list

Item	Quantity	Reference design	Description	Inventory check	Cost
1	1		Metal chassis 5 inches by 6 inches (12.7 x 15.2 centimetres), 26 gauge		
2	1	V_1	Socket, 7- or 9-pin min. tube		
3	2	TB_1, TB_2	Term. strip, 5 Lug		
4	1	TB_3	Term. strip, 3 Lug		
5	5		Machine screw, 4-40 x $^3/_8$ inch (1 centimetre)		
6	5		Nuts, 4-40 x $^3/_{16}$ inch (0.47 centimetre)		

Wiring chart

From	*To*	
V1-1	V1-5	______
V1-2	V1-4	______
V1-1 (S)	TB1-D	______
Progress check		________
V1-2 (S)	TB1-E	______
V1-3 (S)	TB1-A	______
V1-4 (S)	TB1-B	______
V1-5 (S)	TB2-E	______
V1-6 (S)	TB2-B	______
V1-7 (S)	TB2-A	______
TB1-A	TB2-E	______
TB1-A (S)	TB1-C (S)	______
TB1-B (S)	TB1-E	______
TB1-D (S)	TB2-A	______

From	*To*	
TB1-E (S)	TB2-B	______
TB2-A (S)	TB2-C	______
Progress check		________
TB2-B (S)	TB2-D	______
TB2-C (S)	TB3-B (S)	______
TB2-D (S)	TB3-A	______
TB2-E (S)	TB3-C	______
TB3-A (S)	Lead*	______
TB3-C (S)	Lead**	______

*Lead—4-inch (10.2-centimetre) red lead for positive battery connection.

**Lead—4-inch (10.2-centimetre) black lead for negative battery connection.

Name ____________________

Procedure

Chassis Construction:

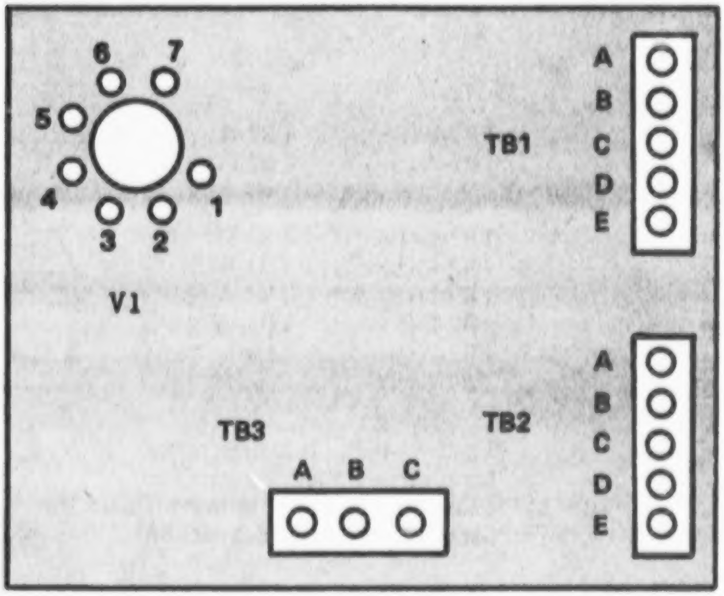
1. Using the dimensions from the chassis layout diagram (or a layout template) and a scriber, mark your metal for the location of fold lines and holes. If you use a template, be sure the template is positioned with the correct side up.
2. Using a hand punch, make the holes for the machine screws and tube socket. Holes labeled X are ⅛ inch (0.3 centimetre) in diameter; therefore, use a ⅛-inch (0.3-centimetre) punch. Holes labeled Z are ¼ inch (0.6 centimetre) in diameter, so use a ¼-inch (0.6-centimetre) punch. If you mark the center of each hole with a center punch, it will be very easy to locate the holes accurately.
3. Using the ⅝-inch (1.6-centimetre) chassis punch, enlarge the ¼-inch (0.6-centimetre) hole to a ⅝-inch (1.6-centimetre) hole.
4. Using the box and pan brake, bend the two sides of the metal chassis. Align the bend lines marked on your metal with the edge of the fingers on the brake, and make a 90-degree bend.
5. Mount the tube socket and terminal strips on the chassis using the machine screws and nuts. Be sure the nuts are on the back side of the chassis. See the attached drawings for location of parts.
6. Using masking tape, label the terminal strips and tube socket. Number the tube pins and letter the lugs on the terminal strips.

Progress Check ____________________

General Wiring Instructions:

1. Check off each item on the wiring table as you complete each step.
2. Use your own judgment for the best layout or routing of the wires.
3. Solder all connections. An (S) after a location on the wiring table indicates that all the wires on that terminal should be soldered. Do not solder any wires unless an (S) appears.
4. Lace or tie the wire bundle.
5. Tin the wire before connecting it to the terminal.
6. When making a wire connection, loop the wire around the terminal only once.

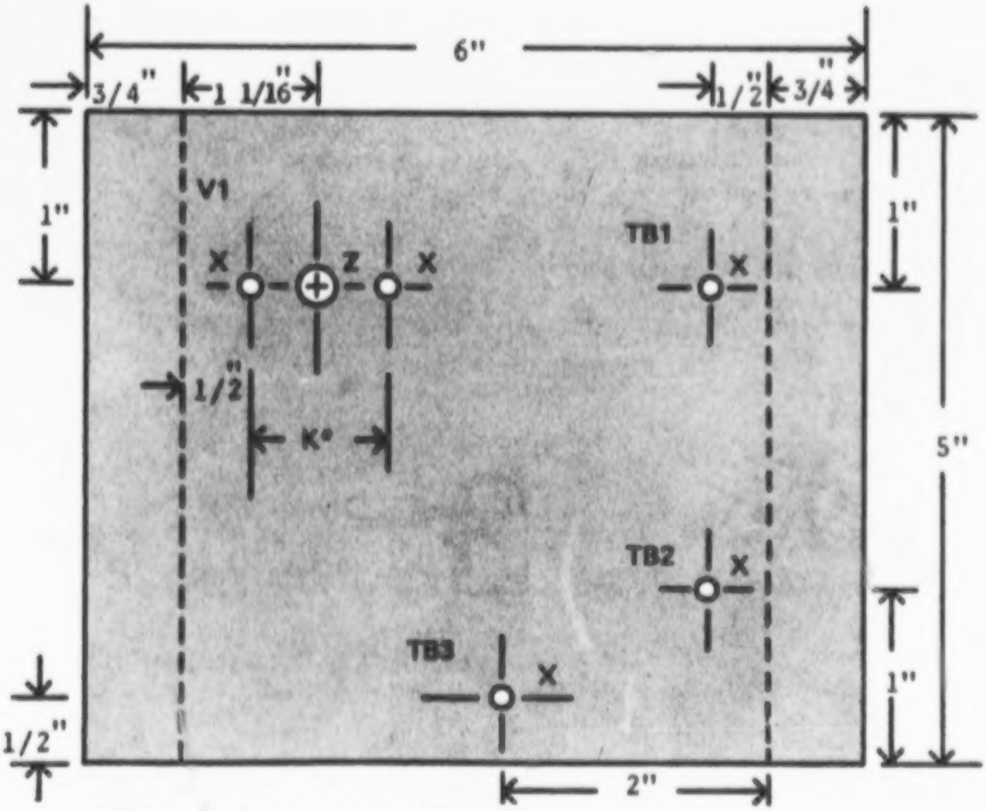
Parts Placement:



Note: V1 may be a 7- or 9-pin tube socket.

Name ______________________

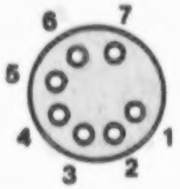
Chassis Layout:



*K—Punch to fit either a 7- or a 9-pin socket.

Project Testing:

Connect the project leads (red and black) to the appropriate DC power supply (approximately 6 VDC): red lead to the positive terminal and black lead to the negative terminal, and turn on the power supply. The project consists of a four-branch parallel circuit. If the circuit is wired correctly, the supply voltage will appear at the tube-socket terminals in the polarities shown below. If a test fixture wired with LEDs or incandescent pilot lamps is plugged into the tube socket, all the LEDs or pilot lamps should light; if not, or if a short condition is indicated, proceed to troubleshooting.



Negative: Potential will appear at pins 1, 3, 5, and 7.

Positive: Potential will appear at pins 2, 4, and 6.

Name ______________________

Troubleshooting:

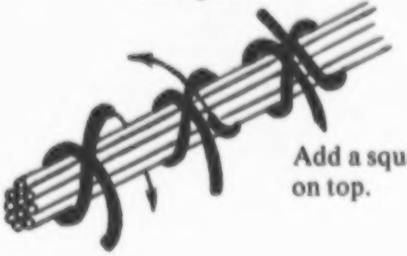
Do not despair; problems are usually minimal and easily solved. Use the following outline to help in finding your problem:

1. Look for any bridges or shorts caused by solder or crossing bare wires. Check the following:
   a. Tube socket terminals
   b. Terminal strip lugs
   c. Wire-to-wire shorts (insulation melted)
2. Wire connected to the wrong terminal*
3. Extra wires*

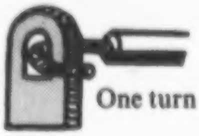
*Use the wiring chart to recheck wire connection points.

Construction Techniques:

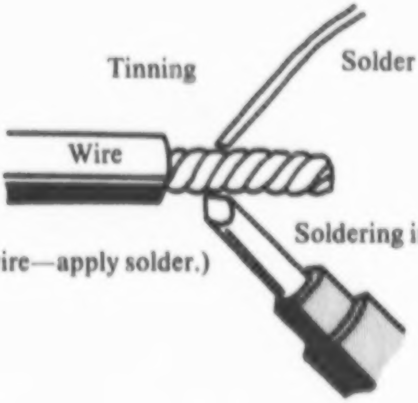
Lacing knot


Add a square knot
on top.

Wire connection


One turn only

Tinning


Solder
Wire
Soldering iron

(Heat wire—apply solder.)

Informational Handout

Guide to Soldering

Introduction

In all electricity/electronics work, high-quality soldering connections are important. Soldering is a process that allows the joining together, both mechanically and electrically, of metal objects (wires, component leads, and so on) through the use of a material called solder and a heating device described as a soldering iron.

Many times soldering is required to make sure that an electrical connection will last for a long time. Proper soldering will also prevent corrosion and add strength.

Soldering Tools and Materials

Always use the correct tools and materials to accomplish the task; remember, proper use of tools and materials will increase your skill and the quality of your work. Check the following list when preparing to solder:

- ☐ Safety glasses
- ☐ Soldering iron and tip of proper wattage (heat)
- ☐ Rosin-core solder—60/40
- ☐ Solder aid
- ☐ Damp sponge
- ☐ Miscellaneous hand tools
- ☐ Bench vise

Soldering Procedures

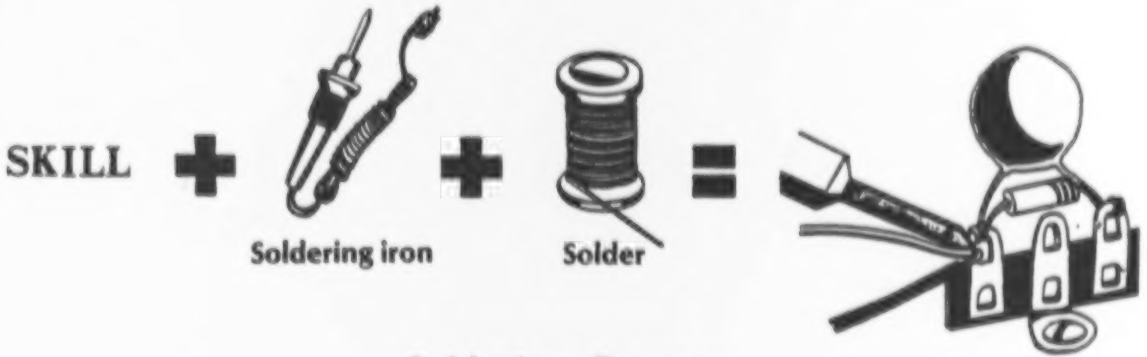
Proper soldering technique requires the learning of a skill, and the best way to learn a skill is to practice. You should follow these procedures each time you must solder:

Obtain tools and materials.
Plug iron in and clean tip.
Tin the tip.
Prepare parts to be soldered.
Make mechanical connection.
Protect heat sensitive parts.
Apply solder.
Do not move parts.
Make visual check.

Inspection

Check your work immediately on completion to avoid making a poor soldering connection. Poor connections generally involve the three problems identified below. You can correct each of these problems by applying the indicated remedies:

Soldering Error	*Remedy*
Not enough solder used	Apply more solder.
Too much solder used	Remove excess and reflow.
Improper heat application (cold solder joint)	Reheat and remove solder; then reflow.



Soldering Process

Desoldering Process

Sometimes, you will have to remove soldered wires or parts from a chassis or printed circuit board. The components must first be desoldered (desoldering is basically the reverse of the soldering process). You should follow the procedures below each time you desolder:

Obtain tools and materials.
Plug iron in and clean tip.
Tin the tip.
Keep tip clean with damp sponge.
Grasp wire or lead.
Apply heat.
Apply pressure/use solder-removing tool.
Remove part.
Check visually, and clean up.

Safety

1. When "resting" a soldering iron, always use a soldering iron holder or stand.
2. Always hold a soldering iron by the handle. When reaching for the iron, be alert and be careful never to grab the hot tip.
3. Do not splash hot solder around by shaking the iron when soldering or desoldering.

Informational Handout

General Assembly and Construction Hints

Without a doubt the fastest, easiest, and most enjoyable way to develop practical electronic skills is by building a project or kit. Basic assembly and construction hints are given in this handout to assist you in becoming a skilled builder. Use the following suggestions whenever possible:

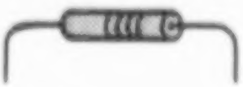
Chassis Wiring or Hand Wiring

- Secure wires and leads so that they are positioned neatly and lie flat against the chassis.
- Cut component wires to the proper lengths before installing them.
- Use insulating tubing (spaghetti) on all wires that may touch each other or that could touch the chassis.
- Wrap wire around the terminal before soldering. Merely inserting the wire through the hole or slot does not make a satisfactory connection.
- As a general rule, remove ¾ inch (1.9 centimetres) of insulation from each end when preparing hookup wires for connection.
- To avoid breaking internal connections when stripping insulation from the leads of the components, hold the leads with pliers while they are being stripped.
- Trim the leads to proper lengths before making the connection for soldering; leads on components are usually longer than needed to complete the connection. As a rule, a lead should be just long enough to complete the connection.
- If the wire is stranded, make sure to twist the individual strands tight and tin the end of the wire before inserting it into the terminal.
- Place the components in a manner that allows their value to be read without moving the part around.
- Cut off any excess component lead or wire from terminals after they have been mechanically secured.

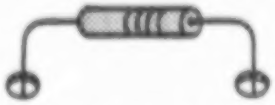
PC Component Mounting

- In wiring or soldering to printed circuit boards, make certain there are no solder tails crossing over from one printed electrical path of copper to another.
- Avoid overheating the printed circuit copper. A soldering pencil or small iron (approximatley 30 watts) is ideal for use in circuit board work.
- Make holes that have been drilled on a PC board slightly larger than the wire or component lead that is to be used.
- Position PC components flush against the circuit board when possible.
- Insert components or wire to stick out, if possible, about $^1/_{16}$ to $^1/_{32}$ of an inch (0.2 centimetre) on the copper side; then bend the wire or component flat and solder. Be careful not to use too much heat when soldering.
- Position all resistors so that their coded value can easily be read in a glance from left to right.

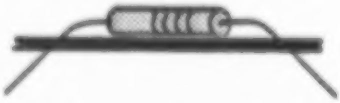
Detail View of Component Mounting on PC Board



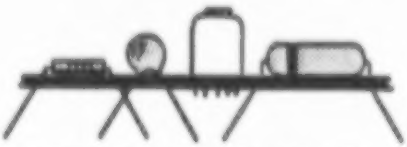
1. Bend the leads.



2. Insert the leads through the proper holes from the noncopper side of the printed circuit board.



3. Position the component next to the printed circuit board and bend the leads to hold them in place.



4. Make sure the placement is correct.

Informational Handout

Electrical Connections

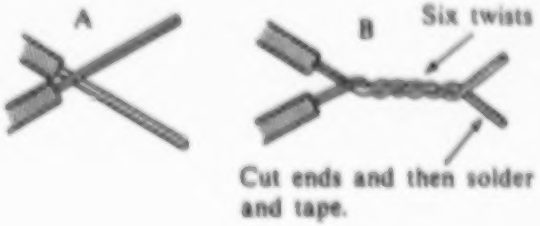
Electrical connections and electrical circuits must be reliable, and only a skilled solderer can guarantee reliability. Remember, it takes a great deal of practice to learn a skill, including soldering.

Common Splices

Hand-formed wire connections are called splices. The three most commonly used splices are the rat-tail, tap or tee, and Western Union.

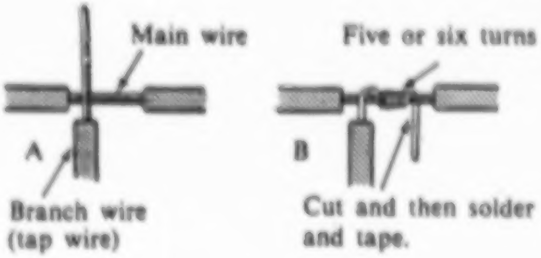
The Rat-tail Splice

The rat-tail splice is generally used in cases where wires are to be joined together. The rat-tail joint is often used in an electrical junction box, like those in homes. The splice should be soldered and taped, or a solderless connector (wire nut) should be used, before the box cover is replaced. If wire sizes below AWG 14 are used, the splice cannot be formed by hand. Pliers should be used for twisting, and care should be exercised not to damage the wires. Follow the examples at the right when making this splice.



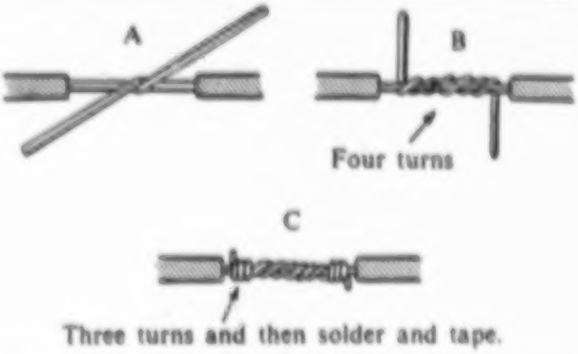
Tap or Tee Splice

The tap or tee splice is also found primarily in home electrical wiring circuits. It is used to connect a branch conductor to one wire that runs through a junction box. The advantage of this splice is that the main wire is not cut; it is just stripped where the branch wire is joined. This splice should be soldered and taped before the box cover is replaced. Follow the examples at the right when making this splice.



Western Union Splice

The Western Union splice is the strongest of the three splices and the most interesting one to make. It is used to splice a break or cut in a long wire or to extend a wire a few more feet if it is short. This splice should be soldered and taped when completed. It has a unique history attached to its name: When the Western Union Telegraph Company had problems with breaks in telegraphic wires, its workers would use this splice to repair the wire. Follow the examples at the right when making this splice.

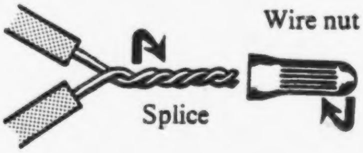


Solderless Connectors

Solderless connectors or wire nuts can be used generally to splice wires up to size AWG 6.

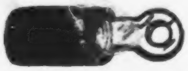
Wire Nuts

The most common solderless connectors are of the twist-on variety. This electrical hardware item is handy when one does not have the opportunity to solder or when a quick yet strong mechanical electrical connection is necessary. Follow the example below when using this kind of connector.

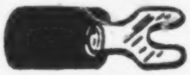


Solderless Terminal Lugs

Solderless or crimp-type terminals are used sometimes as a means to provide a strong metal-to-metal bond (terminal-to-wire) without the use of the soldering process. Two common types are the fork- and ring-tongue styles.

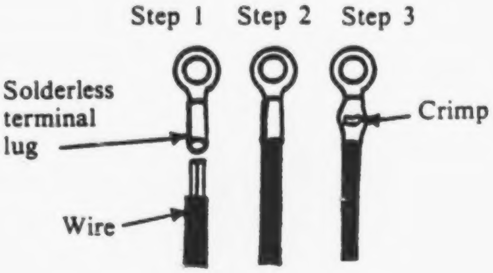


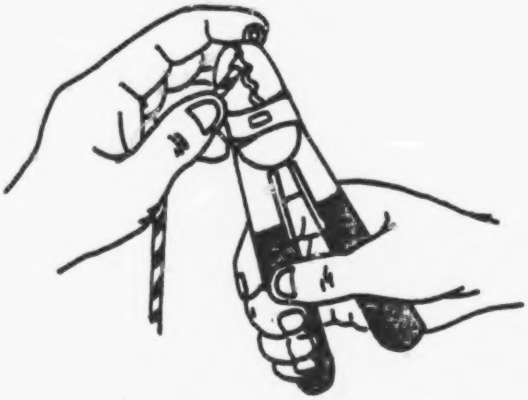
Ring tongue



Fork tongue

The style selected depends on the specific use. To connect either one to wire requires a crimping tool. Check the example below for proper installation technique.





Step 3 requires this kind of crimping tool.

Informational Handout

Printed Circuit Board Fabrication

START

↓

Cut board to size.

↓

Clean board.

↓

Transfer circuit pattern onto board.

↓

Apply resist material.

- Paint on nail polish, lacquer, or resist paint.
- Lay down dry transfer patterns and burnish.
- Use PC tape and donuts, press down firmly, and burnish.
- Draw over pattern with resist pen.

↓

Etch board.

↓

Remove resist material.

↓

Clean PC board with steel wool.

↓

Drill out lead and mounting holes as necessary.

↓

STOP

Informational Handout

Printed Circuit Board Fabrication—Photographic Method

START

↓

Design artwork.

↓

Photograph artwork (transparency).
Negative
Positive

↓

Cut board to size.

↓

Thoroughly clean board and dry.

↓

Coat board with photosensitive resist.

- Brush
- Spray
- Dip
- Spin

↓

Bake board.

↓

Expose board and superimposed transparency to ultraviolet light.

↓

Develop board.

↓

Rinse and postbake.

↓

Etch board.

↓

Remove resist material.

↓

Clean PC board with steel wool.

↓

Drill out lead and mounting holes as necessary.

↓

STOP

Score ________

Grade________

Name ______________________

Date ______________________

Period ______________________

Project Evaluation Sheet

Project______________________________ Construction dates ____________ to ____________

	Excellent	Good	Average	Poor	Unacceptable
Finish (paint labeling, and so forth)					
Assembly (techniques and quality)					
Layout and dimensions					
Tool usage					
Design (form/function)					
Use of materials to best advantage					
Good use of time					
Work habits					
Project report					

Comments

Answer Key
for Unit 5

	T	F		
	1	2	3	4
1.		■		
2.		■		
3.	■			
4.	■			
5.	■			
6.		■		
7.		■		
8.		■		
9.	■			
10.	■			
11.		■		
12.		■		
13.	■			
14.	■			
15.	■			
16.		■		
17.	■			
18.	■			
19.		■		
20.		■		
21.	Tinning			
22.	Rosin flux			
23.	Conductor joint splice			
24.	Heat sink			
25.	Clean			

Tool and Hardware Identification

1. File
2. Center punch
3. Electric hand drill
4. Hacksaw
5. Phillips head screwdriver
6. Long-nose pliers
7. Wire stripper
8. Diagonal pliers
9. Drill bit
10. Ball peen hammer
11. Bench vise
12. Drill press
13. Adjustable wrench
14. Greenlee chassis punch
15. Shear
16. Slip-joint pliers
17. Lineman's pliers or electrician's pliers
18. Nut driver
19. Standard screwdriver
20. Soldering iron
21. Open end wrench
22. Box pan brake
23. Reamer
24. Printed circuit board
25. Chassis
26. Wire tie
27. Whitney hand punch
28. Desoldering tool
29. Solder
30. Solderless or crimp-type terminal
31. Stranded wire
32. Heat sink
33. Wire nut
34. Metal shear

Soldering, Splices, and PC Fabrication

(Answers will vary.)

Activity

(Answers will vary.)

Unit 6

Magnetism

Title of Unit: Magnetism

Time Allocated: Two weeks

Unit Goal

To broaden the student's competence in evaluating the influence that magnetism has on our lives and to discover its relationship to electricity

Unit Objectives

The student will be able to do the following:

1. Give the properties of magnetism and list ten electrical or electronic devices which use magnetism in one form or another.
2. Identify the characteristics of magnetic lines of flux, and, when given a magnet with the pole polarity labeled, indicate the direction of the lines of flux, both internal and external.
3. Explain the basic laws of magnetism as related to the poles of a magnet and describe the earth's magnetism in reference to its geographical poles.

Evaluation

The student will demonstrate his or her competence in the unit objectives on the basis of performance criteria established by the individual instructors. The criteria may include a combination of written, oral, and laboratory testing procedures.

Instructor's Reference

Gerrish, Howard, and William Dugger, Jr. *Electricity and Electronics.* South Holland, Ill.: Goodheart-Willcox Co., 1980.

Overview

Several important fundamental competencies are presented in this unit as a basis for several later units in this guide and for units in the guides for more advanced levels.

Most students know some of the basic properties of magnets through their own experiences; hence, the subject matter is not foreign and quite easy to introduce.

Stress the influence that magnetism has on the lives of everyone, and then trace the historical background of magnetism prior to making the technical presentation.

The next topic of emphasis should be the basic laws of magnetic attraction and repulsion. During instruction on this subject, a discussion about the earth's magnetism would be appropriate.

Suggested Presentation Hints/Methodology

Use this unit as a basic guideline for presenting the curriculum; however, note the following:

1. When demonstrating magnetic lines of flux with a magnet and iron filings, be careful not to use an excessively strong magnet. A strong magnet will not perform adequately, because it will force the filings into groups rather than a uniform pattern.
2. To obtain inexpensive magnets for classroom demonstrations, consider government surplus stores as prime vendors. Usually, this kind of merchandise can be purchased at such stores at a price far below that of most commercial distributors. If it is more convenient, locate a livestock supply house or a dairyperson who uses bar magnets for protection of livestock. Ask for any discarded magnets. Cows are sometimes given a small bar magnet to swallow to protect their inner stomachs from foreign objects which they might accidently swallow.
3. When discussing temporary magnets and their characteristics, describe electromagnets as the major subcategory. Many electromagnets can and should be demonstrated, along with such inexpensive devices as relays, electric bells, and solenoids.

Supplemental Activities and Demonstrations

The following supplemental activities and demonstrations are suggested for use in presenting the curriculum:

1. A good activity for this unit would be to have the students build a simple electric motor kit. This

kind of motor is generally designed for beginning kit builders and is sold complete with a manual that includes information on the how and why of its operation.

2. In any demonstration of magnetic principles, a magnet or magnets should be placed on the stage plate of an overhead projector and covered with a clear plastic sheet. Use a shaker to sprinkle some iron filings on top of the sheet, and then discuss the pattern that is created. This demonstration also provides an opportune time to discuss magnet polarity and the basic law of magnetism.

Instructional Module Contents

1. Lecture Outline (overhead)
2. Pretest and Post-test (keyed)
3. Technical Glossary
4. Work Sheet (vocabulary)—Word Decoding
5. Activity
6. Informational Handout (Classification of Magnets)
7. Informational Handout (Magnetism and Magnetic Fields)
8. Answer Key for Unit 6

Unit 6

Magnetism

(Lecture Outline)

A. Magnetic Force

B. Early Use of Magnets

C. Types of Magnets

D. Lines and Fields of Magnetic Force
   1. Basic law of magnetism
   2. The poles of a magnet

E. Earth's Magnetism

F. Compass Usage

G. Magnetic and Nonmagnetic Materials

H. Magnetism and Its Relation to Electricity

I. Daily Uses of Magnetism

J. Magnetizing and Demagnetizing

Test number ________

Examination for Unit 6

Magnetism

Write your answers to the questions on the answer sheet. Fill in the box that corresponds to the correct answer to the question. Each question has only one correct answer.

1. Copper, aluminum, and steel are magnetic materials. (T-F)

2. A permanent magnet is one that cannot be destroyed or weakened. (T-F)

3. It is never necessary or desirable to demagnetize a material or object. (T-F)

4. Alnico is a natural magnet. (T-F)

5. Most metallic materials exhibit magnetic properties. (T-F)

6. As magnetic poles are moved apart, magnetic attraction or repulsion decreases. (T-F)

7. Heating, striking, or placing a magnet within an alternating current field will increase its magnetic strength. (T-F)

8. Magnetic flux lines "flow" or extend from the N-pole to the S-pole. (T-F)

9. The earth's magnetic field is similar to the field developed by a bar magnet. (T-F)

10. The needle of a compass points toward the earth's geographic North Pole. (T-F)

11. Which of the following surrounds a magnet?

    1. A negative charge
    2. A current
    3. A voltage
    4. A magnetic field

12. A magnet which keeps its magnetism for only a short time is:

    1. A permanent magnet
    2. Made of soft iron
    3. A temporary magnet
    4. Both 2 and 3

13. A magnetic field is believed to be made up of:

    1. North or south poles
    2. Orbiting electrons
    3. Flux lines
    4. Glass

14. The basic law of magnetism states that:

    1. Unlike poles repel.
    2. Like poles repel.
    3. Two south poles attract.
    4. Like poles attract.

15. As one moves away from the poles of a magnet, the density of the flux lines:

    1. Decreases
    2. Increases
    3. Remains the same
    4. May increase or decrease, depending on the magnet

16. In the process of magnetizing a piece of steel, the magnetic ________ within the material are aligned in one direction.

17. Which of the following is not a permanent magnet material?

    1. Steel
    2. Soft iron
    3. Alnico
    4. Iron/cobalt

18. Which pole of a magnet has the most magnetic strength?

    1. N-pole
    2. S-pole
    3. Both poles
    4. Neither pole

19. Which of the following operates by magnetism or magnetic force?

    1. Electric motor
    2. Electric buzzer
    3. Solenoid
    4. All of the above

20. Other than magnetic stroking, a steel bar can be magnetized by:

    1. Placing it within an AC field
    2. Striking it
    3. Heating it
    4. Placing it within a DC field

21. The point of a magnet where the magnetic force is most concentrated is called a ________.

22. A north magnetic pole will attract a ________ magnetic pole.

23. The first permanent magnets were composed of an iron ore called ________ or lodestone.

24. Materials that are attracted to a magnet or that exhibit magnetic characteristics are called ________ materials.

25. Electromagnets are actually a type of ________ magnet.

Technical Glossary

Attraction—The process of drawing or pulling toward an object; for example, a magnet will attract a piece of soft iron.

Basic law of magnetism—A law that explains the interaction of magnetic fields. The law states that like poles repel and unlike poles attract.

Compass—A device which uses the earth's magnetic field and a pivoted magnet needle to indicate direction.

Ferromagnetic material—A classification for materials which are attracted by a magnet. These magnetic materials include iron, nickel, cobalt, and so forth.

Flux lines—The lines of magnetic force which exist around a magnet.

Geographic pole—The axis points of the earth, such as the geographic South Pole.

Keeper—A piece of soft iron placed across the poles of a magnet to confine the magnetic field within the magnet and to avoid demagnetizing.

Magnet—A piece of iron, or a special alloy, which exerts an invisible force of attraction on materials such as iron, nickel, or cobalt.

Magnetic field—The space around a magnet which is influenced or affected by the magnetic force of the magnet.

Magnetic north pole—One of the earth's two magnetic poles. The earth's magnetic north pole is located approximately 1,000 miles (1609 kilometres) south of the geographic North Pole, in northern Canada. The magnetic south pole is actually some 1,500 miles (2413.5 kilometres) from the geographic South Pole, on the continent of Antarctica.

Magnetic pole—The portion of a magnet where the lines of force are most concentrated. In every magnet there is one north-seeking pole (N-pole) and one south-seeking pole (S-pole).

Magnetic shield—A magnetic material used to route magnetic lines of force around an object. This prevents the object from being affected by the magnetic field.

Magnetism—The invisible force exerted by a magnet that allows it to attract ferromagnetic materials and to attract or repel other magnets or magnetic fields.

Magnetite—A blackish iron ore which, in its natural state, contains magnetic particles. Once these particles are aligned, the material will become magnetic and attract other ferromagnetic materials.

Natural magnet—A material, such as lodestone or magnetite, which, in its natural state, exhibits the qualities of a magnet.

Permanent magnet—A manufactured magnet which, when magnitized, will retain its magnetism. Steel and alnico are examples of materials which can be made into permanent magnets.

Repulsion—The process of pushing away or forcing back an object. A north pole of a magnet will repel the north pole of a second magnet.

Temporary magnet—A manufactured magnet that loses its magnetism soon after the magnetizing force is removed. Magnetized soft iron is an example of a temporary magnet.

Score ________

Grade ________

Name ____________________

Date ____________________

Period ____________________

Work Sheet

Word Decoding

The words below have little meaning until they are decoded. Each letter actually represents another letter in the alphabet. The example will get you started in decoding the other scrambled words listed on the work sheet.

Example:

A. GED — A. MAN

1. GEZDSR — 1. ____________________

2. GEZDSRTNG — 2. ____________________

3. LAGCENN — 3. ____________________

4. ERRKELR — 4. ____________________

5. KSCSJ — 5. ____________________

6. MSSCSK — 6. ____________________

7. DAKRW — 7. ____________________

8. CSKGEDSDR — 8. ____________________

9. VSKKAGEZDSRTL — 9. ____________________

10. GEZDSRTRS — 10. ____________________

11. RSGCAKEKP — 11. ____________________

12. GEZDSRTL NWTSJO — 12. ____________________

Score ________

Grade ________

Name ____________________

Date ____________________

Period ____________________

Work Sheet

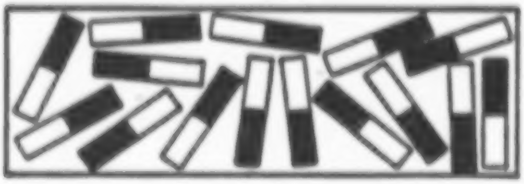
Activity

Matching

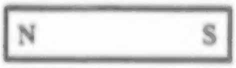
Match the term with the appropriate statement.

1. Lodestone	A. A suspended magnetic needle	1. ____________
2. Compass	B. The total area around a magnet which contains flux lines	2. ____________
3. Repel	C. Two north poles brought close together	3. ____________
4. Ferromagnetic material	D. Electromagnet or soft iron	4. ____________
5. Magnetizing	E. A natural magnet	5. ____________
6. Attract	F. Nickel	6. ____________
7. Magnetic field	G. Striking or heating a magnet	7. ____________
8. Magnetic shield	H. One north pole and one south pole brought close together	8. ____________
9. Demagnetizing	I. A soft iron material used to route flux lines around an object	9. ____________
10. Temporary magnet	J. Drawing a permanent magnet along a steel bar	10. ____________

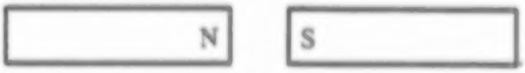
11. The drawing below shows an unmagnetized steel bar. Using the area provided, make a sketch showing the change in position of the magnetic molecules to form a magnetized piece of steel.



12. Draw a sketch of the magnetic field which surrounds the bar magnet below.

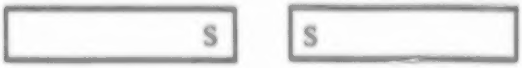


13. Draw a sketch of the field produced by the two magnets below.



Does this field produce attraction or repulsion?

14. Draw the field produced by the two magnets pictured below.



Does this field produce a force of attraction or repulsion?

15. List three practical uses for magnets or magnetic fields.

a.

b.

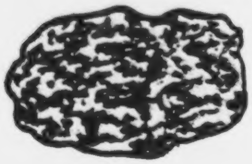
c.

Informational Handout

Classification of Magnets

Any magnet can be classified as either natural, temporary, or permanent. Study each classification listed below and the corresponding description.

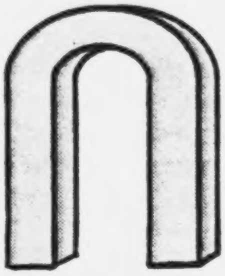
Natural



Lodestone

A natural magnet needs no special treatment by people to make it magnetic. Lodestone (or magnetite) is a natural magnet found on the earth. Especially large quantities can be found in the United States; however, these magnets are very weak and really serve little purpose in the modern world.

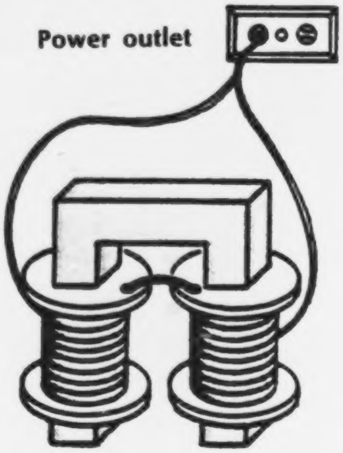
Permanent



Steel Alloy Magnet

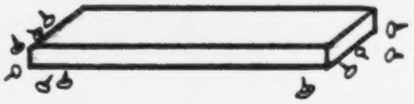
A permanent magnet keeps its magnetism for a long time. This type of magnet is produced from magnetic materials and can be made in a wide variety of shapes and sizes. Permanent magnets are used frequently in electrical appliances, hardware items, and compasses. The term *artificial magnets* is sometimes used to describe either permanent or temporary magnets, but what it really means is that the magnet is manufactured.

Temporary



Electromagnet

Or



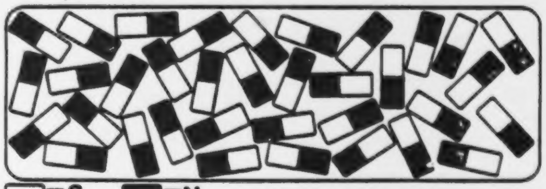
Soft Iron

Temporary magnets are generally of two varieties: those made of materials that do not keep their magnetism long (soft iron) and those which operate with the help of electricity (electromagnets). Electromagnets are temporary in that when electricity is applied, they act like a magnet; however, when the electricity is removed, they do not retain their magnetism.

Informational Handout

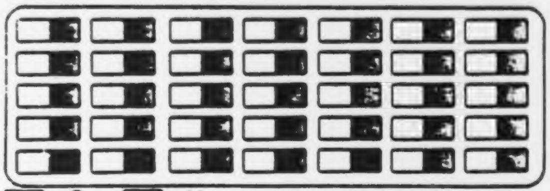
Magnetism and Magnetic Fields

Only certain materials can be magnetized, or attracted by a magnetic field. Natural magnetic materials are called ferromagnetic materials and include the elements iron, nickel, and cobalt. The atoms of these three materials have the peculiar ability to orient themselves so that each atom has a definite positive and negative side. These atoms combine to form magnetic molecules or domains. Each small molecule has a north and south pole. In an unmagnetized piece of iron, for example, these magnetic molecules arrange themselves in a random pattern, as shown below.



☐=S ■=N **Unmagnetized Iron**

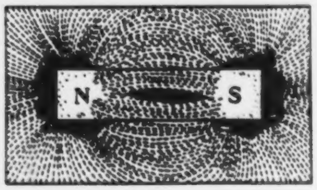
When a material is magnetized, either by contact or by placement within a DC electromagnetic field, the magnetic molecules are forced to move and align themselves in one direction, as shown below.



☐=S ■=N **Magnetized Iron**

Magnetic Fields

The magnetic field of a magnet is composed of a number of invisible lines of force known as flux lines. These flux lines extend from the magnetic poles out into space, flowing from the north pole to the south pole, and not crossing or touching. As the distance from the magnet increases, the separation between the flux lines becomes greater, and the field becomes weaker. The strongest concentration of flux lines is located at the poles of the magnet. Study the diagram of the bar magnet and its associated magnetic field below. Locate the magnetic poles and the areas of dense flux concentration.



Magnetic Field

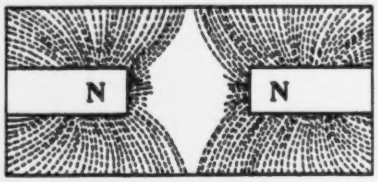
Basic Law of Magnetism

As you probably know from common experience, when two magnets are brought close to each other they will either pull together (attract) or push apart (repel). The action of the two magnets will depend on the orientation of the magnetic poles. The basic law of magnetism explains the magnetic reaction in this way:

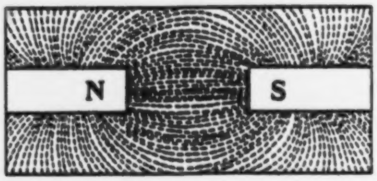
Like poles repel. (N-pole and N-pole as well as S-pole and S-pole repel.)

Unlike poles attract. (N-pole and S-pole attract.)

Fields of magnetic attraction and repulsion are shown below:



Magnetic Repulsion



Magnetic Attraction

Answer Key
for Unit 6

	T	F		
	1	2	3	4
1.		■		
2.		■		
3.		■		
4.		■		
5.		■		
6.	■			
7.		■		
8.	■			
9.	■			
10.		■		
11.				■
12.				■
13.			■	
14.		■		
15.	■			
16.	Domains/ molecules			
17.		■		
18.			■	
19.				■
20.				■
21.	Pole			
22.	South			
23.	Magnetite			
24.	Ferromagnetic			
25.	Temporary			

Word Decoding

1. Magnet
2. Magnetism
3. Compass
4. Attract
5. Repel
6. Keeper
7. North
8. Permanent
9. Ferromagnetic
10. Magnetite
11. Temporary
12. Magnetic shield

Activity

1. E
2. A
3. C
4. F
5. J
6. H
7. B
8. I
9. G
10. D
11. (Small magnets should be lined up horizontally, with all dark ends pointing in the same direction.)
12. (Answers will vary.)
13. (Answers will vary.)
    Attraction
14. (Answers will vary.)
    Repulsion
15. (Answers will vary.)

Unit 7

The Nature of Electricity

Title of Unit: The Nature of Electricity

Time Allocated: One week

Unit Goal

To improve the student's competence in analyzing the characteristics of the atom, the building block of all electrical or electronic circuitry, and to develop in the student a familiarity with the basic units and terms that will be encountered

Unit Objectives

The student will be able to do the following:

1. Identify the basic parts of the atom and give the fundamental laws of charged bodies.
2. Give the definition for both voltage and current and cite the proper units of measurement for each.
3. Connect a simple electrical circuit together and explain the purposes of the individual components, called the supply, control, conductor, and load.

Evaluation

The student will demonstrate his or her competence in the unit objectives on the basis of performance criteria established by the individual instructors. The criteria may include a combination of written, oral, and laboratory testing procedures.

Instructor's References

Seippel, Robert. *Fundamentals of Electricity*. Chicago: American Technical Society, 1974, chapters 1 and 2.

Shrader, Robert L. *Electronic Communication* (Fifth edition). New York: McGraw-Hill Book Company, 1985.

Overview

The students should be informed at the outset of the unit that the study of electrical theory and its applications requires a knowledge of the atom and its basic structure. After this is understood, the next topics can be presented in a more meaningful manner. For example, the law of static attraction and repulsion and the concept of electrons in motion can be better understood by the student if these topics are covered after a discussion of the basic nature of matter.

The instructor should next present and impress students with the difference between potential difference and current flow to encourage a thorough understanding of basic quantities and their proper units of measurement.

The unit concludes with an in-depth evaluation of the electrical makeup of a simple circuit. A variety of appropriate exercises, laboratory experiments, and projects should be coordinated with all unit topics when feasible.

Suggested Presentation Hints/Methodology

Use this unit as a basic guideline for presenting the curriculum; however, note the following:

1. When explaining electron movement or flow, be sure to describe the electron action as a "chain reaction" effect. All too often students believe one electron travels through the circuit at a fantastic speed and operates all the devices it encounters.
2. During the discussion on current flow, refer to the reasons that the current carriers (electrons) always travel toward the positive side of the circuit. Substantiate this concept with the basic law of charged bodies. This kind of foundation will allow students an opportunity to truly understand basic current flow characteristics.
3. To simplify the introduction of measurement units in electricity, find some common ground by asking the class for standard units of measurement for distance, speed, weight, and temperature. After the idea of units of measurement has been established, it is simple to hold a discussion on electrical units of measurement.
4. Develop a couple of simple experiments to illustrate how each basic part of a circuit is used and then explain the fundamental relationship that the parts enjoy with one another.

Supplemental Activities and Demonstrations

The following supplemental activities and demonstrations are suggested for use in presenting the curriculum:

1. Obtain a 3-foot (0.9-metre) acrylic tube with a diameter slightly larger than a Ping Pong ball. Fill the tube (conductor) and perform a variety of demonstrations. Insert one ball and observe the "chain reaction," which will culminate with one ball exiting the opposite end of the tube. Apply a force (voltage) by blowing into the tube and observe the internal flow. Finally, insert a colored ball into one end of the tube. As succeeding balls pop out, keep inserting them into the opposite end and watch the colored ball travel through the tube. Discuss electron flow in terms of this demonstration.
2. If possible, obtain a wall chart of the periodic table of elements and use it during the presentation on the basic structure of the atom. Check with other departments for a possible loan of this visual aid.

Instructional Unit Contents

1. Unit Outline (overhead)
2. Pretest and Post-test (keyed)
3. Technical Glossary
4. Work Sheet (vocabulary)—Crossword Puzzle
5. Activity
6. Informational Handout (Structure of the Atom)
7. Answer Key for Unit 7

Unit 7

The Nature of Electricity

(Lecture Outline)

A. Structure of the Atom

B. The Electron

C. Behavior of Charged Bodies

D. Voltage/Potential Difference

E. Current/Flow of Electrons

F. Units of Measurement

G. Simple Electric Circuit
   1. Supply
   2. Control
   3. Conductor
   4. Load

Test number ________

Examination for Unit 7

The Nature of Electricity

Write your answers to the questions on the answer sheet. Fill in the box that corresponds to the correct answer to the question. Each question has only one correct answer.

1. The atomic number indicates the number of neutrons in the atom. (T-F)
2. A neutral atom has as many electrons as it has protons. (T-F)
3. Basically, the atomic weight of an atom is equal to the number of neutrons plus the number of protons. (T-F)
4. The proton has a negative charge and orbits around the nucleus. (T-F)
5. A conductor is a material which allows current to flow through it. (T-F)
6. The flow of current through a circuit is measured in volts. (T-F)
7. Motors, lamps, bells, and heaters are devices used as loads in electrical circuits. (T-F)
8. A supply provides the source of voltage and current for circuit operation. (T-F)
9. Voltage provides the "pressure" needed to force electrons through a circuit. (T-F)
10. Electrons always flow from negative to positive in an electrical circuit. (T-F)
11. Voltage is measured in the basic unit ________.
12. The ampere is the basic unit of measurement for ________.
13. For a complete electrical circuit, a supply, conductor, load, and ________ are required.
14. Using the information given below, determine the number of neutrons present in the gold atom. ________ neutrons.

Gold **197**
Au
79

15. Electricity travels through a wire or circuit at about the speed of ________.

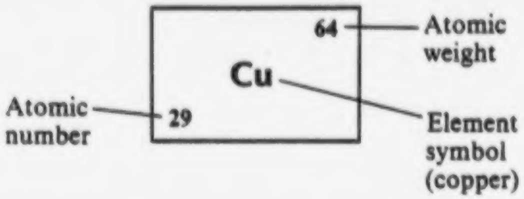
    1. Sound
    2. Wind
    3. Water
    4. Light

Technical Glossary

Ampere—The basic unit of measurement for current. The abbreviation for ampere is A.

Atom—The smallest particle that an element can be divided into and still have all the characteristics of that element. For example, the smallest possible bit of copper that can be removed from a penny is an atom of copper. Atoms contain three basic particles: protons, electrons, and neutrons.

Atomic number—One of two numbers appearing by each element in the periodic table. The atomic number is the smaller of the two numbers and indicates the total number of protons in the nucleus of the particular atom. An example is presented below.



Atomic weight—The second of two numbers appearing with each element in the periodic table. The atomic weight indicates the total mass of the nucleus of the atom.

Complete circuit—An electrical circuit which contains at least a supply, load, control, and conductor. All functional electrical circuits must contain these four basic parts.

Conductor—A material which freely allows current to flow through it. Examples of such material are copper, aluminum, and silver.

Control—The part of a complete circuit which turns on, turns off, or routes (directs) current through a circuit. A switch is an example of a control.

Current—The orderly flow of electrons through an electrical circuit. The abbreviation for current is I.

Electron—The negatively charged particle in an atom. The electrons are located in the shells and orbit around the nucleus.

Electron shell—The location of the electrons within the atom. Each layer of electrons constitutes a shell, and each shell has a maximum possible population.

Load—The device which a circuit is designed to operate. Common circuit loads are motors, lamps, speakers, heating elements, and so forth.

Neutron—An atomic particle that is located in the nucleus of the atom and that is neutral (neither positive nor negative) in charge.

Nucleus—The center mass of an atom which contains the protons and neutrons. The nucleus forms the central "core" of the atom and contains most of the atom's mass.

Proton—An atomic particle that is located in the nucleus of the atom and that has a positive charge.

Supply—The device which provides the necessary voltage and current for circuit operation. Some typical supply devices are batteries, generators, and solar cells. The supply is often referred to as the source.

Valence shell—The outermost electron shell of the atom; also referred to as the "hook." The valence shell is the most chemically and electrically active of the electron shells. It is the valence electrons which basically determine a material's electrical characteristics.

Volt—The basic unit of measurement for voltage. The abbreviation for volt is V.

Voltage—The electrical force or pressure which causes electrons to move through a circuit. Other terms for voltage are electromotive force and potential difference. The abbreviation for voltage is E.

Score ________

Grade ________

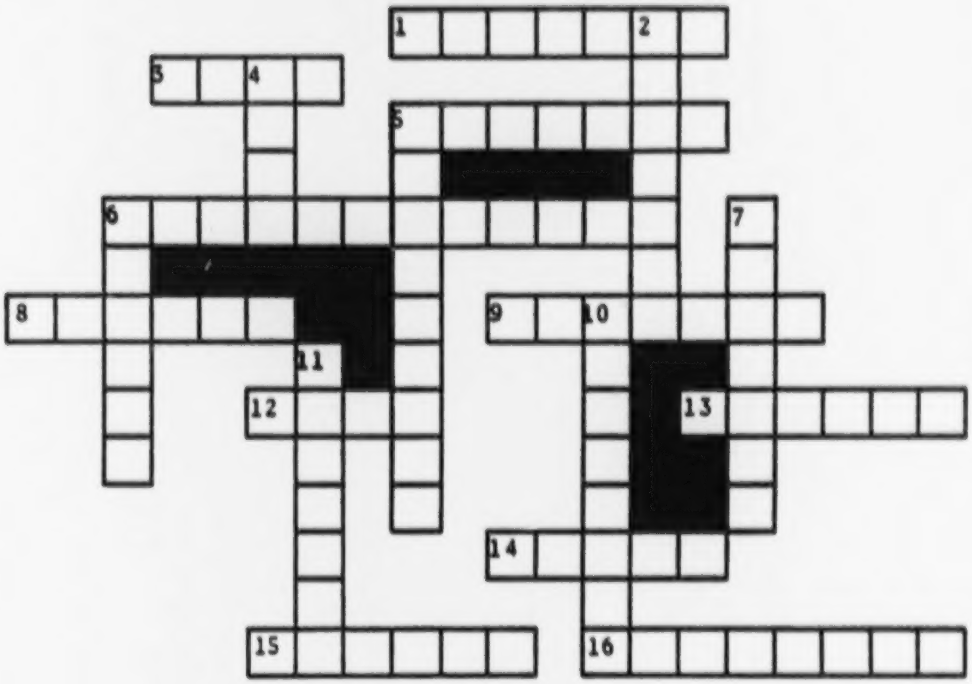
Name ____________________

Date ____________________

Period ____________________

Work Sheet

Crossword Puzzle



Across

1. The outermost electron shell
3. The device a circuit is designed to operate
5. The orderly flow of electrons through a circuit
6. Identifies the number of protons in an atom
8. The part of a circuit which provides the voltage and current for operation
9. The center of the atom
12. The basic unit for voltage
13. The positive particle in the nucleus of the atom
14. The location of electrons in an atom
15. The atomic ______, which indicates the mass of an atom
16. The negative particle in an atom

Down

2. The part of a complete circuit which directs current flow
4. The smallest particle into which an element can be divided
5. A material which allows or supports current flow
6. The basic unit for current flow
7. A neutral particle in the center of the atom
10. An electrical circuit which contains a supply, load, control, and conductor
11. Electromotive force

Score ______

Grade ______

Name ______

Date ______

Period ______

Work Sheet

Activity

1. Electrons orbit around the nucleus of the atom in paths called ______.

1. ______

2. The nucleus of the atom contains both ______ and ______.

2A. ______
2B. ______

3. The atomic ______ indicates the number of protons in the atom.

3. ______

4. A neutral atom will contain the same number of ______ and ______.

4A. ______
4B. ______

5. The outermost electron shell of an atom is called the ______ shell.

5. ______

6. Electromotive force is commonly called ______ and is measured in the basic unit of the ______.

6A. ______
6B. ______

7. The orderly flow of electrons through a circuit is called ______ and is measured in the basic unit of the ______.

7A. ______
7B. ______

8. The smallest particle that an element can be divided into and still retain all the characteristics of that element is called an ______.

8. ______

9. Unlike electrical charges will ______, and like electrical charges ______.

9A. ______
9B. ______

10. A positively charged particle will attract a ______ charged or ______ particle.

10A. ______
10B. ______

11. List the three basic atomic particles and their electrical charges.

11A. ______
11B. ______
11C. ______

12. Draw a sketch of the boron atom.

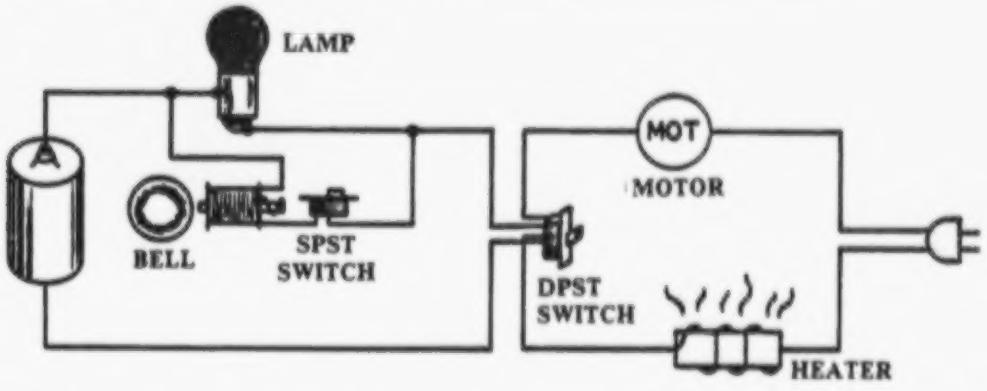
Boron 11
B
5

13. Draw a sketch of the copper atom.

Copper 64
Cu
29

14. Draw a diagram of a simple complete electrical circuit. Label the four characteristic parts of the circuit.

15. Identify the supply, control, load, and conductor elements in the circuit below.


LAMP
A
BELL
SPST SWITCH
MOT
MOTOR
DPST SWITCH
HEATER

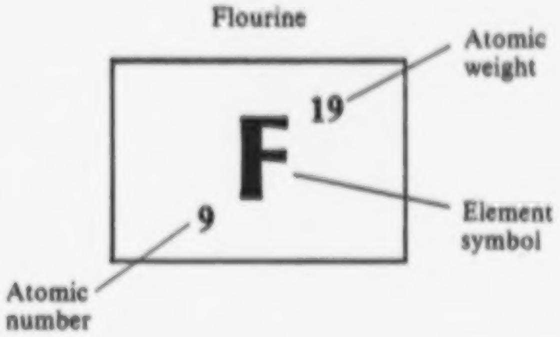
Supply devices	Control devices	Load devices	Conductor element

Informational Handout

Structure of the Atom

Periodic Table Information

The information found in the periodic table of elements includes the name of the element, the element's symbol, and its atomic weight and number.



Drawing of an Atom

To draw an atom, you must know the number of protons, electrons, and neutrons present in the atom. The atomic number provides the number of protons found in the nucleus of the atom. In the pure form, an atom will have an equal number of protons and electrons, so the atomic number actually indicates the total number of protons and electrons. To find the number of neutrons in the atom, simply subtract the atomic number from the atomic weight.

Using the information given about the fluorine atom, you should be able to list the number of protons, electrons, and neutrons found in that atom.

Protons - 9

Electrons - 9

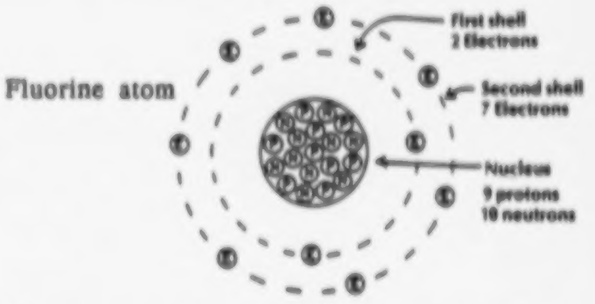
Neutrons - 10

After the above information is determined, a simple sketch of the atom can be made as follows:

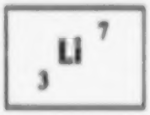
1. Draw the protons and neutrons in the nucleus of the atom, which is located in the center of the diagram.
2. The electrons orbit around the nucleus and are located in the electron shells. Each shell has a maximum possible population, as follows:

First shell	Second shell	Third shell	Fourth shell
2 electrons	8 electrons	18 electrons	32 electrons

The electrons must then be placed in the shells, beginning with shell No. 1. Fill each shell before moving to the next.

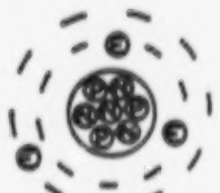


Now that you know the system, use your new knowledge to draw a sketch of the lithium atom.



Protons—
Electrons—
Neutrons—

Compare your sketches with the sketch below.



Answer Key
for Unit 7

	T	F		
	1	2	3	4
1.		■		
2.	■			
3.	■			
4.		■		
5.	■			
6.		■		
7.	■			
8.	■			
9.	■			
10.	■			
11.	Volt			
12.	Current			
13.	Control			
14.	118			
15.				■
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
25.				

Crossword Puzzle

Across

1. Valence
3. Load
5. Current
6. Atomic number
8. Supply
9. Nucleus
12. Volt
13. Proton
14. Shell
15. Weight
16. Electron

Down

2. Control
4. Atom
5. Conductor
6. Ampere
7. Neutron
10. Complete
11. Voltage

Activity

1. Shells
2A. Protons
2B. Neutrons
3. Number
4A. Electrons
4B. Protons
5. Valence
6A. Voltage
6B. Volt
7A. Current
7B. Ampere
8. Atom
9A. Attract
9B. Repel
10A. Negatively
10B. Neutral
11A. Electron –
11B. Proton +
11C. Neutron o
12. (Answers will vary.)
13. (Answers will vary.)
14. (Answers will vary.)
15. *Supply devices*
    Cell
    AC

    Control devices
    DPST switch
    SPST switch

    Load devices
    Lamp
    Bell
    Heater
    Motor

    Conductor element
    Wire

Unit 8

Methods of Producing Electricity

Title of Unit: Methods of Producing Electricity

Time Allocated: One week

Unit Goal

To introduce the student to a variety of methods of producing electricity and to expose him or her to other related energy considerations, such as cost, availability, conservation, and power potential

Unit Objectives

The student will be able to do the following:

1. Identify six methods of producing electricity.
2. Illustrate by example how each of the sources discussed produces electricity.
3. Explain the necessity for energy conservation and methods of conserving energy in the home and discuss the availability of alternative energy sources.

Evaluation

The student will demonstrate his or her competence in the unit objectives on the basis of performance criteria established by the individual instructors. The criteria may include a combination of written, oral, and laboratory testing procedures.

Instructor's References

Steinberg, W. F., and W. B. Ford. *Electricity and Electronics* (Fourth edition). Chicago: American Technical Society, 1972.

Mileaf, Harry. *Electricity One-Seven.* Rochelle Park, N.J.: Hayden Book Company, Inc., 1976, Chapter 1.

Overview

Unit 8 focuses on electricity as an essential part of our lives. Because electricity is so essential, it is important to know how electrical energy is produced.

The instructor should first examine the sources that are available and then identify those which are small-scale sources and those that are classified as large-scale sources in terms of power produced.

This unit introduces the six basic sources of electricity, along with some of the details of application. The actual concept of how these sources generate electricity will be considered later..

Also emphasized are other vital considerations associated with the consumption of energy.

Suggested Presentation Hints/Methodology

Use this unit as a basic guideline for presenting the curriculum; however, note the following:

1. Do not leave the impression that the sources of electricity presented in this unit are the only sources; they are just the most common ones. Explain that many other sources show promise but that they are still in the experimental stages of development.
2. Explore methods of producing electricity in greater depth during laboratory activities in which the student physically examines and/or performs a variety of experiments.
3. During discussions of heat, light, and pressure methods of producing electricity on a small-scale basis, emphasize that these methods are used primarily in controlling or sensing types of circuits.
4. Discuss with the class alternatives to electrically powered entertainment. Ask the students to list leisure activities that they presently participate in and that do not require electricity and then have them describe their feelings about such a situation being a permanent part of their life-styles.
5. Introduce to the class new career choices which may exist in the future in such special energy fields as solar energy, geothermal energy, wind power, and nuclear fusion.

Supplemental Activities and Demonstrations

The following supplemental activities and demonstrations are suggested for use in presenting the curriculum:

1. Producing electricity through heat action can be demonstrated by using a pair of wires (iron and nichrome) and a large galvanometer. Twist the loose ends of the wires together and heat the junction with a match.
2. Producing electricity through pressure action can be demonstrated with a record player pickup.

Apply pressure to the needle and then measure the voltage across the cartridge.

3. Producing electricity through light action can be demonstrated with a measurement of the output of a solar cell. The output will increase as the light striking its face increases.

Instructional Unit Contents

1. Unit Outline (overhead)
2. Pretest and Post-test (keyed)
3. Technical Glossary
4. Work Sheet (vocabulary)—Scrambled Word Puzzle
5. Activity
6. Informational Handout (Six Methods Used to Produce Electricity)
7. Answer Key for Unit 8

Unit 8

Methods of Producing Electricity

(Lecture Outline)

A. Six Sources of Electricity Production
   1. Friction
   2. Chemicals
   3. Heat
   4. Light
   5. Pressure
   6. Magnetism

B. Use of Energy
   1. Home consumption
   2. Conservation of energy
   3. Alternative sources

Test number ________

Examination for Unit 8

Methods of Producing Electricity

Write your answers to the questions on the answer sheet. Fill in the box that corresponds to the correct answer to the question. Each question has only one correct answer.

1. Static electricity is generated by heat. (T-F)
2. When a charged rod is brought close to a neutral material, attraction occurs. (T-F)
3. The two types of static charges are positive and neutral. (T-F)
4. A primary cell can usually be recharged. (T-F)
5. The amount of electrical energy used in the home is measured in kilowatt-hours. (T-F)
6. A battery changes chemical reactions into electrical energy. (T-F)
7. Light shining on a thermocouple will produce a small amount of electricity. (T-F)
8. Moving a magnet into a coil of wire will produce electricity. (T-F)
9. A solar cell is an example of a piezoelectric device. (T-F)
10. Many devices use less energy when they are left on and operating than when they are turned on and off as needed. (T-F)
11. A charged rubber rod will attract:
    1. A charged glass rod
    2. A positively charged material
    3. A neutral material
    4. All of the above
12. The liquid in a wet cell is called the:
    1. Acid juice
    2. Electrolyte
    3. Chemical composition
    4. Electrode
13. Piezoelectricity is electricity produced by:
    1. Heat
    2. Chemical reactions
    3. Pressure
    4. Magnetism
14. A generator requires a coil of wire, motion, and ______ to produce electricity.
    1. Light
    2. Heat
    3. Friction
    4. Magnetism
15. Which of the following is an example of a photoelectric device?
    1. Solar cell
    2. Thermocouple
    3. Battery
    4. Rochelle salt

Technical Glossary

Acid—A strong chemical substance with corrosive properties. Vinegar is an example of a weak acid; other common acids are citric acid and sulfuric acid.

Alternative—Refers to another choice or possible selection. Alternative energy sources could include such things as wind power, solar energy, tidal power, and nuclear power.

Battery—Two or more voltaic cells connected together in either series or parallel. A battery is an important source of direct current (DC) electrical energy because it is self-contained and portable.

Cell—A single voltaic unit which is formed by combining two dissimilar metals and an acid solution.

Chemical electricity—A source of DC electricity which is produced by chemical reactions. A cell and a battery are examples of chemical electrical devices.

Coil—A number of turns of insulated wire, usually wrapped in circular form. A coil of wire is a necessary part or element in a generator.

Conservation—The process of saving or limiting the use of a resource, such as electrical energy.

Consumption—The act of using up or consuming a resource, such as electrical energy.

Dissimilar—Referring to materials that have different characteristics. Two dissimilar metals, for example, are copper and zinc.

Energy—A force which is capable of doing work. Common sources of energy include electricity, steam, falling water, nuclear reactions, and combustion (fire).

Generator—A device used to produce electricity, either AC (alternating current) or DC, by moving a coil of wire through a magnetic field or by keeping the coil stationary and moving the magnetic field.

Photoelectricity—A source of DC electricity which is released or produced by light energy. The three types of photoelectrical devices are photovoltaic, photoconductive, and photoemissive. Only the photovoltaic devices produce electricity directly from light.

Piezoelectricity—A source of electricity which is produced when varying pressure is applied to a certain crystal material, such as quartz, Rochelle salts, or barium titanate.

Primary cell—A type of voltaic cell which will produce electricity as soon as the chemicals are combined. The cell generally cannot be recharged.

Secondary cell—A cell which requires charging before it will produce electricity. The cell has the advantage of being continually rechargeable.

Static electricity—A collection of electrical charges (both positive and negative) at rest on the surface of an object. Static charges are generated or produced by friction.

Thermocouple—A device consisting of two dissimilar metals joined at a junction. When the junction is heated, a small amount of DC electricity is produced.

Score ________

Grade ________

Name ________________

Date ________________

Period ________________

Work Sheet

Scrambled Word Puzzle

Unscramble the letters below to determine the electronic terms.

A. EECCIITTRYL	A. ELECTRICITY
1. LECL	1. ________
2. CADI	2. ________
3. TICTAS	3. ________
4. NEERYG	4. ________
5. TABEYRT	5. ________
6. LCCHAEIM	6. ________
7. TEENGORRA	7. ________
8. SMILSIRDAI	8. ________
9. LEARNATEVIT	9. ________
10. CATNOSENORIV	10. ________
11. RDAOECSYN	11. ________
12. TPNMSCNOOIU	12. ________
13. EEERZPLCCIIIOYTT	13. ________
14. MOTORHEELCUP	14. ________
15. TELETOPHOTRYCCII	15. ________

Score ________

Grade ________

Name ____________________

Date ____________________

Period ____________________

Work Sheet

Activity

Choose from the list below ten common household appliances that you use most frequently. Then, locate and record the wattage rating for each of the items. Normally, the ratings can be found stamped into the body of the appliance or on a metal plate affixed to the device. Record your findings in the spaces provided.

Common Household Appliances

Wattage rating	Device
________	Air conditioner (room)
________	Black and white TV
________	Blender
________	Blow dryer
________	Clock
________	Clock radio
________	Coffee maker
________	Color TV
________	Curling iron
________	Drill (portable)
________	Electric blanket
________	Electric can opener
________	Electric typewriter
________	Electronic TV game
________	Fan
________	Food processor
________	Fry pan

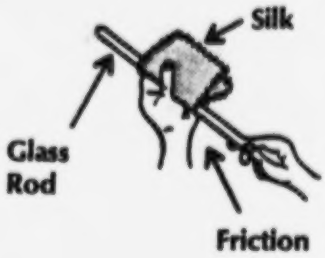
Wattage rating	Device
________	Hot curlers
________	Hot plate
________	Iron
________	Lamps and lighting
________	Mixer
________	Oven, microwave
________	Popcorn popper
________	Projector
________	Radio
________	Stereo/receiver
________	Sewing machine
________	Shaver
________	Sunlamp
________	Tape recorder
________	Toaster
________	Vacuum cleaner
________	Waffle iron

Answer the following questions after you have completed your research.

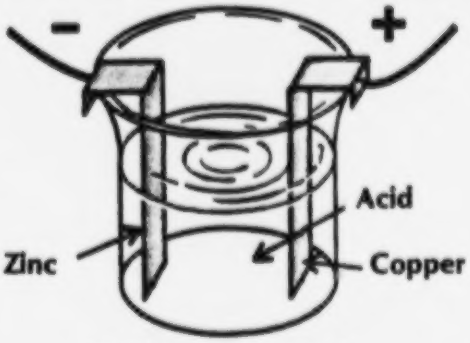
1. Which device has the highest wattage rating?
2. Which device has the lowest wattage rating?
3. Which device do you use most often?
4. On your list, which devices have the highest wattage ratings? Do they include those without heating elements or those with heating elements?
5. Which device consumes the most energy over the period of one week? (Consider wattage rating and time of use.)
6. What practical things could you do to reduce your consumption of electrical energy?

Informational Handout

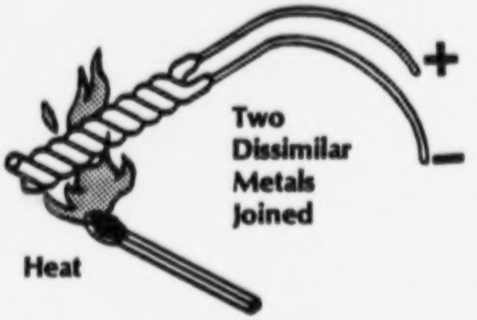
Six Methods Used to Produce Electricity


Silk
Glass Rod
Friction

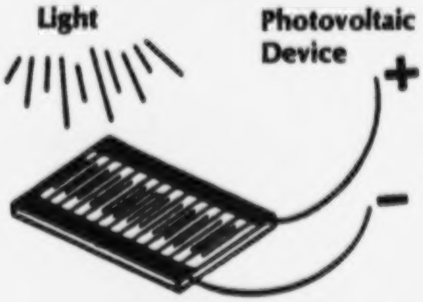
Electricity from friction
(static electricity)


-
+
Acid
Zinc
Copper

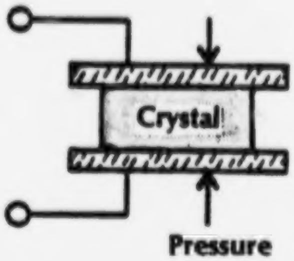
Electricity from chemicals
(chemical electricity)


+
-
Two Dissimilar Metals Joined
Heat

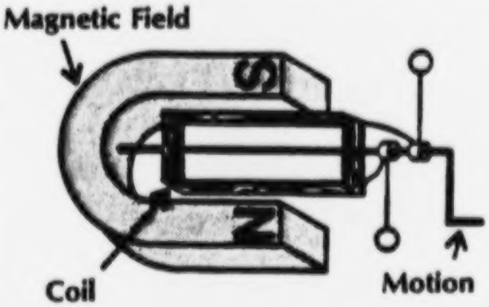
Electricity from heat
(thermoelectricity)


Light
Photovoltaic Device
+
-

Electricity from light
(photoelectricity)


Crystal
Pressure

Electricity from pressure
(piezoelectricity)


Magnetic Field
S
N
Coil
Motion

Electricity from magnetism
(magnetoelectricity)

Answer Key
for Unit 8

	T	F		
	1	2	3	4
1.		■		
2.	■			
3.		■		
4.		■		
5.	■			
6.	■			
7.		■		
8.	■			
9.		■		
10.	■			
11.				■
12.		■		
13.			■	
14.				■
15.	■			
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
25.				

Scrambled Word Puzzle

1. Cell
2. Acid
3. Static
4. Energy
5. Battery
6. Chemical
7. Generator
8. Dissimilar
9. Alternative
10. Conservation
11. Secondary
12. Consumption
13. Piezoelectricity
14. Thermocouple
15. Photoelectricity

Activity

(Answers will vary.)

Unit 9

Electrical Flow Through Conductors, Insulators, and Semiconductors

Title of Unit: Electrical Flow Through Conductors, Insulators, and Semiconductors

Time Allocated: One week

Unit Goal

To acquaint the student with the general characteristics of specific materials, including their electrical properties, thus helping the student to comprehend the methods used to classify materials as conductors, insulators, and semiconductors.

Unit Objectives

The student will be able to do the following:

1. Differentiate between the characteristics of conductors, insulators, and semiconductors and identify specific examples of materials that are included in each category.
2. Describe the fundamental purposes and importance of conductors and insulators and their uses in conjunction with electrical or electronic circuits.
3. Demonstrate the ability to strip properly both solid and stranded wire and verbally list the correct procedures for doing so.

Evaluation

The student will demonstrate his or her competence in the unit objectives on the basis of performance criteria established by the individual instructors. The criteria may include a combination of written, oral, and laboratory testing procedures.

Instructor's References

Kaufman, Milton, and J. A. Wilson. *Basic Electricity: Theory and Practice*. New York: McGraw-Hill Book Company, 1973, Chapter 3.

Matt, Stephen R. *Electricity and Basic Electronics*. South Holland, Ill.: Goodheart-Willcox Company, Inc., 1977, Chapter 3.

Overview

This unit should be used to continue the ongoing investigation of properties of practical types of conductors, insulators, and semiconductors.

Unit 5 touched on some basic electrical/mechanical skills; Unit 9 deals with the specific electrical performance characteristics of materials and is designed to expand the student's competence in identifying, handling, and preparing wire.

The main lecture theme of this unit is that all materials may be classified electrically. A particular classification can be determined by the number of electrons which can be easily forced out of their specific orbits. This classification is sometimes described as the number or availability of free electrons.

Suggested Presentation Hints/Methodology

Use this unit as a basic guideline for presenting the curriculum; however, note the following:

1. This unit provides an opportunity to explain some related factors that should be considered when selecting or preparing conductors, such as types of wire, braids, multiple-wire cables, wire sizes, wire harnesses, lacing, and wire color code.
2. A variety of laboratory activities are provided to assist students in developing or reviewing basic mechanical and electrical skills. Simple exercises on wire identification, techniques of wire stripping, or methods of fabricating wire harnesses can help introduce students to many basic assembly procedures.
3. Stripping of stranded wire is given little attention by many instructors; however, the correct technique is sometimes difficult for students to learn. When teaching this skill, make an effort to explain what happens electrically and mechanically when strands are broken during the stripping process.
4. Generally, teachers focus entirely on conductors in this kind of unit; remember not to overlook

emphasizing insulators as a major subject topic. Two main discussion points are that (1) insulators are rated by the amount of voltage required to break down their insulating properties; and (2) insulators are selected on the basis of the surroundings in which they will function.

Supplemental Activities and Demonstrations

The following supplemental activities and demonstrations are suggested for use in presenting the curriculum:

1. Create a visual display of an assortment of wires and their protective coverings (insulation). Materials can be mounted on a board and labeled to facilitate examination. Safety should be stressed in the use of insulation.
2. To help the student understand the function of a conductor or insulator in an electrical circuit, use a simple operating lamp circuit with a means to cut in and cut out a test section for checking material conductivity. Use a variety of material samples and observe the lamp for individual conductivity characteristics.
3. Bring in a container full of different types of insulators and have the students try to determine the applications of each one.

Instructional Unit Contents

1. Unit Outline (overhead)
2. Pretest and Post-test (keyed)
3. Technical Glossary
4. Work Sheet (vocabulary)—Know Your Definitions
5. Activity
6. Informational Handout (Current Flow Through a Conductor)
7. Informational Handout (Purpose and Application of Wire)
8. Answer Key for Unit 9

Unit 9

Electrical Flow Through Conductors, Insulators, and Semiconductors

(Lecture Outline)

A. Classification
   1. Conductors
   2. Insulators
   3. Semiconductors

B. Characteristics of Current Flow

Test number ________

Examination for Unit 9

Electrical Flow Through Conductors and Insulators

Write your answers to the questions on the answer sheet. Fill in the box that corresponds to the correct answer to the question. Each question has only one correct answer.

1. A conductor provides a path through which electrons can flow freely. (T-F)
2. Plastic is a common conductor used on wires. (T-F)
3. Semiconductors contain five valence electrons. (T-F)
4. An insulator offers a difficult path for electron flow. (T-F)
5. Gold has the lowest resistance to current flow and is known as the best conductor. (T-F)
6. The effect of an electric current moves at approximately the speed of light. (T-F)
7. Semiconductor materials have few uses in the field of electronics; thus, they are not important substances. (T-F)
8. For electrons to flow through a wire, a voltage must first be applied. (T-F)
9. Stranded wire consists of one very flexible central conductor coated with an insulator, such as rubber. (T-F)
10. Electrons flow through a circuit from negative to positive. (T-F)
11. Copper and aluminum are the two most common conductor materials. (T-F)
12. Glass or ceramic insulators are used when very high voltage is present. (T-F)
13. The best conductor for general electronic work is:
    1. Copper
    2. Aluminum
    3. Silver
    4. Tin
14. Good insulators:
    1. Have eight electrons in their valence shells.
    2. Are compounds.
    3. Do not conduct electricity.
    4. Include all of the above.
15. A semiconductor acts:
    1. As an insulator at high temperature
    2. As either an insulator or a conductor
    3. As a conductor when it contains no impurities
    4. All of the above

Technical Glossary

Chain reaction—A series of events which occur in rapid order due to some input or "starting" action. The toppling of a line of dominoes and the flow of electrons through a wire are common examples of chain reactions.

Chemical stability—An indication of an atom's tendency to mix or react with other atoms. Generally, an atom with a full valence shell (eight outer electrons) will be very stable and, thus, not react chemically or electrically. An atom with only one valence electron, on the other hand, is very unstable and, thus, very chemically or electrically active.

Conductor—A material through which an electrical current will easily flow. Conductors contain many free electrons which contribute to current flow. The best conductors contain only one valence electron and are metals. Silver, gold, and copper are the three best conductors for electrical current flow.

Dielectric—A term used to describe an insulator; thus, a dielectric material is also an insulating material.

Electrical impulse—The chain reaction caused when an electron is forced into a circuit, simultaneously causing another electron to leave the circuit. This electrical impulse, or chain reaction, continues throughout the circuit at the speed of light as long as pressure is applied.

Free electron—An electron which is removed from the valence shell of its atom, usually by electrical pressure, and is free to move through a wire or circuit. Free electrons moving in the same direction through a conductor produce an electric current.

Insulator—A material which does not allow current flow. Insulators contain few free electrons and, therefore, do not provide an easy path for current flow. The best insulators contain eight valence electrons and are compounds such as plastic or glass.

Semiconductor—A material that can act as either an insulator or a conductor, depending on its temperature or chemical purity. Semiconductors contain four valence electrons, and the most common examples are silicon and germanium.

Speed of light—The speed at which light travels through free space. This speed has been established as 300,000,000 metres per second. An electrical impulse will travel through a conductor at the speed of light.

Stripping—The process of removing the insulating material (plastic, cloth, enamel) from a wire or conductor.

Score ________

Grade________

Name ______________________________

Date ______________________________

Period ______________________________

Work Sheet

Know Your Definitions

Using your own words, develop a short definition for the following terms:

1. Conductor
2. Insulator
3. Semiconductor
4. Free electron

For the following terms, include a sketch to enhance and clarify your word definitions.

5. Chain reaction
6. Electrical impulse

Score ________

Grade________

Name ____________________

Date ____________________

Period ____________________

Work Sheet

Activity

For items 1-20, use a simple experimental device or technique (continuity tester, ohmmeter, simple series lamp circuit) or conduct research (textbook and/or chemical handbook) and classify the following materials as either conductors, insulators, or semiconductors. Write your responses in the spaces provided.

1. Copper ________________
2. Plastic________________
3. Cloth________________
4. Steel ________________
5. Enamel________________
6. Gold ________________
7. Silicon ________________
8. Glass________________
9. Ceramic ________________
10. Silver ________________
11. Germanium ________________
12. Aluminum ________________
13. Mica________________
14. Paper ________________
15. Carbon ________________
16. Wood ________________
17. Air________________
18. Lead ________________
19. Paraffin wax ____________
20. Tin ________________

21. The purpose of a conductor is:

22. The purpose of an insulator is:

23. List the three best conductors for electrical current flow.
    A. ____________ B. ____________ C. ____________

24. The wire most commonly used for electrical conductors is made of soft ________.

25. Conductors contain many ________ electrons.

26. The most common semiconductor materials are silicon and ________.

27. Wire strippers are designed to remove the ________ from wires.

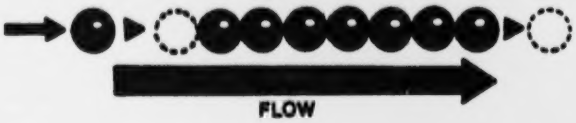
28. List one desirable feature of solid wire.

29. Name one advantage that stranded wire has over solid wire.

30. When a power cord is made of a heavy gauge wire with thick plastic insulation or asbestos cloth insulation, what does such wire indicate about the load device?

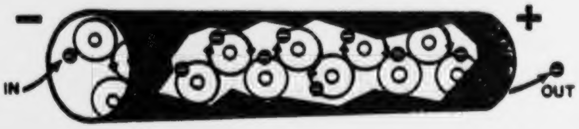
Current Flow Through a Conductor

The flow of electrical current is caused by an orderly flow of electrons through a circuit or conductor. Each time an electron enters a wire or conductor, another electron is forced out of that conductor. This action is similar to the flow of energy through a long row of billiard balls, as shown below:



When the first ball is struck, the force is transferred from ball to ball until the last ball is forced from the row.

In a conductor, the valence electrons of the copper atoms in effect become the billiard balls. As the source or voltage forces an electron into the wire, the electron enters a nearby valence shell, forcing out the resident electron. The free electron, in turn, enters another nearby valence shell, forcing out its resident electron. This procedure continues until an electron exits the end of the wire. Although the procedure seems complex, it occurs at a very rapid speed of 300,000,000 metres per second, or the speed of light.



The electrical phenomenon pictured above is known as an electrical impulse.

It may seem peculiar, but an individual electron moves rather slowly through a wire—approximately 10.92 millimetres per second—but the total effect of an electrical current travels at the speed of light, which is 186,000 miles (299 274 kilometres) per second.

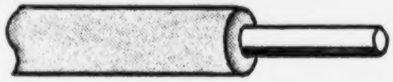
Informational Handout

Purpose and Application of Wire

Purpose

Wire is an essential part of all electrical circuits, and you should review some of the important factors given below when selecting or using wire.

A conductor (wire) provides the path or highway for the movement of electrons. Many times wire is covered with insulation to keep the current safely within the wire.



Conductor + Insulator = Wire
Conductor − Insulator = Bare Wire

Types of Wire

Solid wire is usually made from one thick copper thread. It is easy to handle and to solder; however, when a lot of physical movement is necessary, this kind of wire should not be used. This wire can be purchased in a variety of outside colors and sizes. Components like resistors, capacitors, inductors, and transformers have solid wires (leads) extending from the body of the device so that the component may be connected securely to the circuit. Solid wire is used to complete electrical circuits in the walls of homes, schools, and commercial buildings.

Solid wire

Stranded wire

Stranded wire is made from a bunch or group of copper threads that have been twisted together to appear like one wire. When flexibility is important, this is the type of wire to use. One must remember to be careful when stripping this kind of wire; some of the strands could be destroyed, causing the wire to be both mechanically weak and unable to handle all of the current flow. Stranded wire is generally tinned with solder before being connected to a circuit point. This wire is used in cables, appliances, and extension cords.

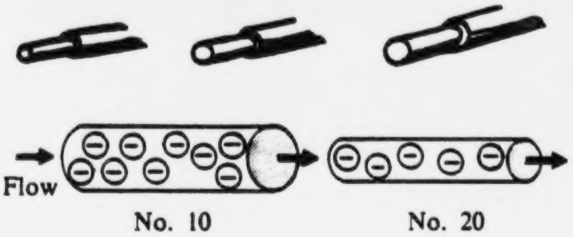
Wire Insulation

Most wires are covered by some kind of insulating material to prevent short circuits and dangerous accidents. Look below at the various types of coverings associated with each kind of wire.

Solid wire insulation	*Stranded wire insulation*
Enamel	Rubber
Varnish	Plastic
Plastic	Cloth
Rubber	Fiberglass

Wires Sizes

The American Wire Gauge (AWG) number is a system of describing by number the size or electrical capacity of wire. The larger the wire number, the smaller the diameter of the wire. Of course, it is important to select the proper size of wire for the job at hand. (NOTE: A wire gauge is a device that can be used to determine the size of wire.)



A No. 20 wire can carry less current than a No. 10 wire because the No. 20 wire is physically smaller in size; hence, less current can travel through this wire.

Wire in General

Most wire is now made from copper because it is such a good conductor of electricity and can be purchased at a good price. Silver is rated as a better conductor, but it is seldom used by manufacturers because of its cost.

Answer Key for Unit 9

	T	F		
	1	2	3	4
1.	■			
2.		■		
3.		■		
4.	■			
5.		■		
6.	■			
7.		■		
8.	■			
9.		■		
10.	■			
11.	■			
12.	■			
13.	■			
14.				■
15.		■		
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
25.				

Know Your Definitions

1. (Answers will vary.)
2. (Answers will vary.)
3. (Answers will vary.)
4. (Answers will vary.)
5. (Answers will vary.)
6. (Answers will vary.)

Activity

1. Conductor
2. Insulator
3. Insulator
4. Conductor
5. Insulator
6. Conductor
7. Semiconductor
8. Insulator
9. Insulator
10. Conductor
11. Semiconductor
12. Conductor
13. Insulator
14. Insulator
15. Conductor
16. Insulator
17. Insulator
18. Conductor
19. Insulator
20. Conductor
21. To allow current to flow
22. To block the flow of current

23A. Silver
23B. Gold
23C. Copper

24. Copper
25. Free
26. Germanium
27. Insulation
28. (Answers will vary.)
29. (Answers will vary.)
30. The load will draw considerable current.

Unit 10

Electrical Units of Measurement

Title of Unit: Electrical Units of Measurement

Time Allocated: Two weeks

Unit Goal

To investigate and transmit competencies for identifying fundamental electrical quantities and their units of measurement and to establish students' competence in the measurement techniques that are necessary for monitoring these quantities

Unit Objectives

The student will be able to do the following:

1. Identify and differentiate between the basic types of electrical quantities and their corresponding units of measurement.
2. Compare and contrast the application of meters used in measuring simple electrical quantities.
3. Demonstrate the proper techniques to use when reading a typical meter scale and explain the necessity of an accurate measurement.

Evaluation

The student will demonstrate his or her competence in the unit objectives on the basis of performance criteria established by the individual instructors. The criteria may include a combination of written, oral, and laboratory testing procedures.

Instructor's References

Buban, Peter, and Marshall L. Schmitt. *Understanding Electricity and Electronics.* New York: McGraw-Hill Book Co., 1976.

Hickey, Henry V., and William M. Villines. *Elements of Electronics.* New York: McGraw-Hill Book Co., 1980.

Mileaf, Harry. *Electricity One-Seven.* Rochelle Park, N.J.: Hayden Book Company, Inc., 1976, chapters 2 and 5.

Overview

This unit introduces several basic competencies which can be used as a basis for succeeding technical units throughout this level as well as future levels.

The content of the unit should be presented carefully. First, it must be stressed that electrical quantities must be defined and that these quantities operate together when performing within a circuit. Once definitions and functions are firmly established in the mind of the student, it is relatively easy for him or her to associate letter symbols or units of measurement with the proper quantity.

The next major topic should deal with measuring procedures and meter usage. This area of instruction may be critical for successful laboratory work. Without adequate instruction, students may have great difficulty understanding meter usage.

Suggested Presentation Hints/Methodology

Use this unit as a basic guideline for presenting the curriculum; however, note the following:

1. When explaining terminology, be aware that first exposure to technical expressions often leads to misunderstanding by the student. Spend a significant amount of time reviewing what the terms *voltage, current,* and *resistance* mean and then briefly explain their relationship with each other.
2. Do not be afraid to use repetition as a means to teach students about specific units of measurement and letter symbols. Use the chalkboard to list a variety of terms and/or units and then let the students match up the correct pairs.
3. Reemphasize major instructional points periodically, because meters and measurement are vital instructional concepts, especially for future laboratory work. Illustrate methods of meter connections, use managers or advanced students to assist in supervision and instruction, and coordinate measurement activities so that electrical quantities are not measured in succession (E, I, and R). Careful presentation of this topic will enable you and the students to maintain a positive attitude about the laboratory. Since time allocation is always so critical in the classroom, focus your attention on meters common to your laboratory. Note that, at this level, many instructors omit laboratory exercises based on ammeter usage because of obvious problems in misuse.

Supplemental Activities and Demonstrations

The following supplemental activities and demonstrations are suggested for use in presenting the curriculum:

1. Write to manufacturers on school stationery and ask for free visual aids or handout materials on meters and measurement. Addresses are easy to obtain from such large meter manufacturers as Simpson, Triplett, Weston, and RCA by simply contacting the local electronic parts dealer. Ask for classroom sets; if less material arrives, make a bulletin board display.
2. Budget an appropriate amount of time for instructing less able students on ruler or scale reading. Many average students have difficulty reading an ordinary measuring device, so use this as a beginning point and then transfer this kind of measurement reading to meter scales and their divisions.
3. Demonstrate a variety of meters; however, try to include small panel meters, meter instruments, and digital measuring devices.

Instructional Unit Contents

1. Unit Outline (overhead)
2. Pretest and Post-test (keyed)
3. Technical Glossary
4. Work Sheet (vocabulary)—Glossary Cryptics
5. Work Sheet—The Shop Meter
6. Work Sheet—Reading Meter Scales
7. Activity
8. Informational Handout (The Electrical Team)
9. Informational Handout (How to Use a Meter to Measure Voltage or Resistance)
10. Informational Handout (Procedures in Reading a Meter)
11. Answer Key for Unit 10

Unit 10

Electrical Units of Measurement

(Lecture Outline)

A. Basic Electrical Quantities
   1. Voltage
   2. Current
   3. Resistance

B. Letter Symbols

C. Units of Measurement

D. Meters for Measuring Electrical Quantities

Test number ________

Examination for Unit 10

Electrical Units of Measurement

Write your answers to the questions on the answer sheet. Fill in the box that corresponds to the correct answer to the question. Each question has only one correct answer.

1. The letter symbol for voltage is V. (T-F)
2. Voltage and electromotive force mean the same thing. (T-F)
3. The symbol ∞, which appears on some ohmmeter scales, means infinity. (T-F)
4. Zeroing a meter is necessary to achieve accurate measurements. (T-F)
5. Electron flow in a DC circuit is always from negative to positive. (T-F)
6. To measure a DC voltage drop, connect the meter across a resistor and observe polarity. (T-F)
7. When a resistance measurement is taken, the circuit being tested may be left on or turned off. (T-F)
8. Both current and voltage move or flow through a circuit. (T-F)
9. The function switch on a meter is used to set the needle or pointer to zero. (T-F)
10. When an unknown value of voltage is measured, the meter range switch should be set in its highest position. (T-F)
11. The basic unit of measurement for voltage is the:

    1. Watt
    2. Ohm
    3. Ampere
    4. Volt

12. The letter symbol for current is:

    1. C
    2. I
    3. A
    4. E

13. Ω is the electrical symbol for the:

    1. Volt
    2. Ampere
    3. Resistor
    4. Ohm

14. The orderly flow of electrons through a circuit is known as:

    1. Current
    2. Electromotive force
    3. Resistance
    4. Power

15. The electrical quantity which opposes the flow of electrons through a circuit is called:

1. Voltage	3. Ohm
2. Resistance	4. Current

16. A multimeter is generally able to measure:

1. Voltage	3. Resistance
2. Current	4. All of the above

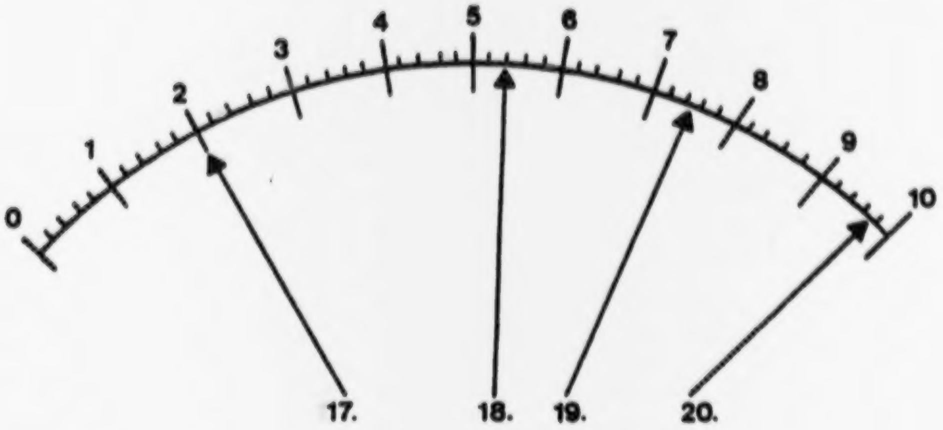
For questions 17 through 20, read and record the values indicated by each pointer/scale combination.

17. ____________________

18. ____________________

19. ____________________

20. ____________________



133

Technical Glossary

Ammeter—An instrument designed to measure the flow of electrical current. The symbol for the ammeter is —Ⓐ—

Ampere—The basic unit of measurement for current flow.The letter symbol for ampere is A.

Current—The orderly flow of electrons through a circuit. Current is typically measured in amperes or amps. However, milliamperes and microamperes are also used. The letter symbol for current is I.

Deflection—The movement of the meter pointer from the zero position.

Digital multimeter—A multimeter whose input or measured value is displayed directly as illuminated digits or numbers. The abbreviation for digital multimeter is DMM.

Electromotive force—The pressure that causes electrons to move through a circuit; also referred to as voltage. The letter symbol for electromotive force is E, and the abbreviation is EMF.

Function switch—A meter control used to select the electrical quantity (voltage, current, or resistance) to be measured.

Infinity—An extremely large value that continues indefinitely. The symbol for infinity is ∞.

Mechanical zero—An adjustment to the meter movement which mechanically sets the meter pointer on zero. This adjustment is necessary for accurate measurement.

Meter—A device to measure electrical quantities, such as voltage, resistance, and frequency. The symbol for meter is —Ⓜ— . The letter symbol for meter is M.

Multimeter—A meter designed to measure more than one electrical quantity. Most multimeters can measure AC and DC voltage, AC and DC current, and resistance.

Needle—The indicating device on a meter; sometimes called the pointer. The needle and scale are used together to read the indicated value.

Ohm—The basic unit of measurement for resistance. The letter symbol for ohm is Ω.

Ohmmeter—An instrument used to measure electrical resistance in ohms. The symbol for ohmmeter is —(Ω)— .

Polarity—The property of a device or circuit determining the direction in which current flows. The quality of having two opposite charges, one positive (+) and the other negative (-). Polarity can also refer to the quality of having two opposite magnetic poles, one north and one south.

Range switch—A basic meter control used to select the maximum value which the meter can measure. Many times the range switch is used as a multiplier.

Resistance—A measure of the opposition that a component or circuit offers to the flow of an electric current. Resistance is measured in the basic unit ohms; however, kilohms and megohms are also used as units of measurement. The letter symbol for resistance is R.

Scale—The line or arc on an instrument's face, with graduations or increments that have assigned values.

Score ________

Grade ________

Name ________________

Date ________________

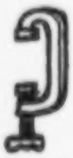
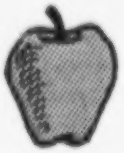
Period ________________

Work Sheet

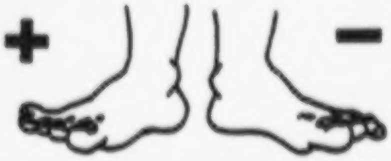
Glossary Cryptics

Decode the cryptic messages below and identify the electronic term that sounds similar to the answer.

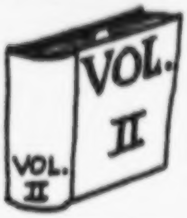
Example:

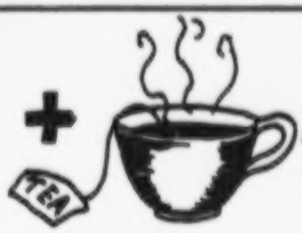
X +  – **Cl** +  – **Ap**

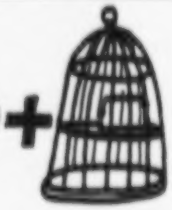
A. Example

M +  – **F** + **R**

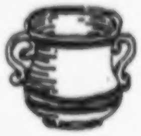
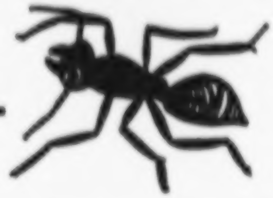
1. ________



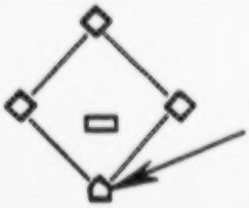
+ 

+  – **C**

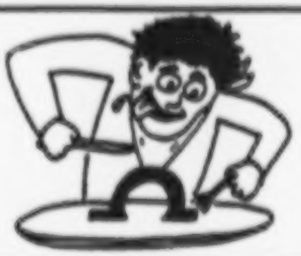
2. ________

C +  – **N** + 

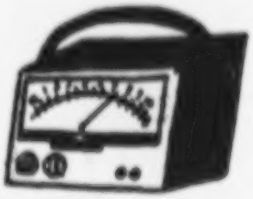
3. ________

 – **h** – **plate**

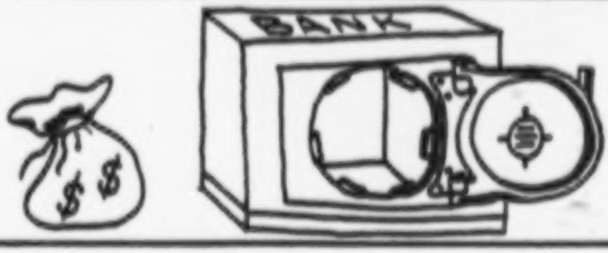
4. ________



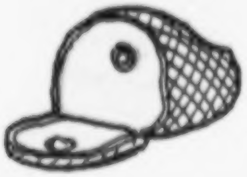
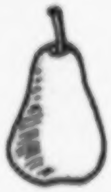
5. ______________

$$\begin{array}{r} 7 \\ \times\ 3 \\ \hline 21 \end{array}$$ − ply + 

6. ______________



7. ______________

 − h + 

8. ______________

Score ________

Grade ________

Name ________________________

Date ________________________

Period ________________________

Work Sheet

The Shop Meter

In the space provided below, make an accurate drawing of the shop meter. Label all controls and terminals.

In the space provided below, describe the purpose of the shop meter. Why is the meter such an important piece of testing equipment?

Score ________

Grade________

Name ______________________________

Date ______________________________

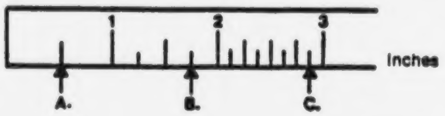
Period ______________________________

Work Sheet

Reading Meter Scales

Read and record the values that are indicated by the scale/pointer combinations below.

1.

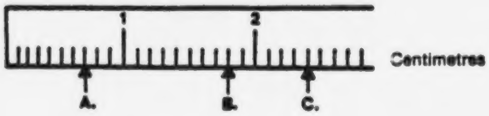

1
2
3
Inches
A.
B.
C.

1A. ______________________

1B. ______________________

1C. ______________________

2.

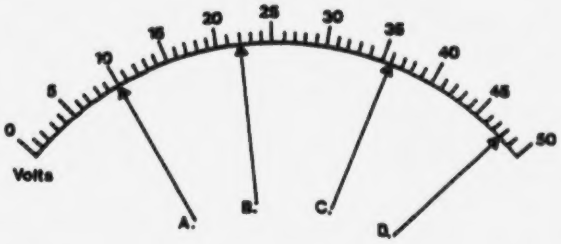

1
2
Centimetres
A.
B.
C.

2A. ______________________

2B. ______________________

2C. ______________________

3.


0
5
10
15
20
25
30
35
40
45
50
Volts
A.
B.
C.
D.

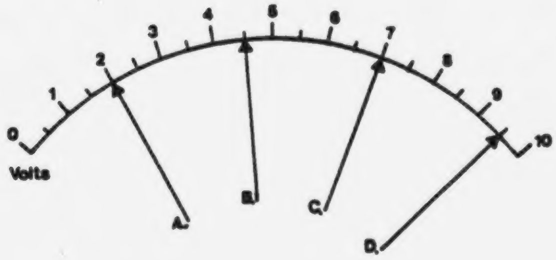
3A. ______________________

3B. ______________________

3C. ______________________

3D. ______________________

4.


0
1
2
3
4
5
6
7
8
9
10
Volts
A.
B.
C.
D.

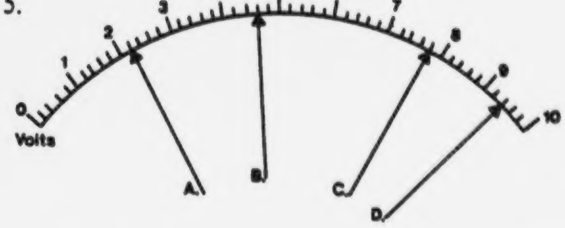
4A. ______________________

4B. ______________________

4C. ______________________

4D. ______________________

5.


0
1
2
3
4
5
6
7
8
9
10
Volts
A.
B.
C.
D.

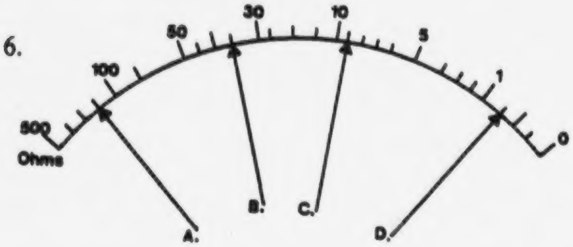
5A. ____________________

5B. ____________________

5C. ____________________

5D. ____________________

6.


500
100
50
30
10
5
1
0
Ohms
A.
B.
C.
D.

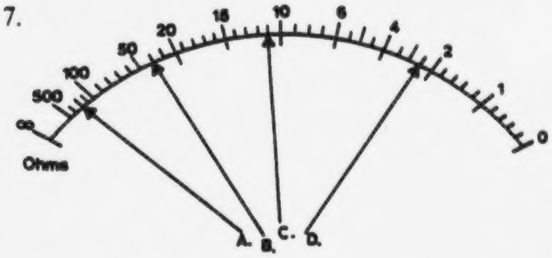
6A. ____________________

6B. ____________________

6C. ____________________

6D. ____________________

7.


∞
500
100
50
20
15
10
6
4
2
1
0
Ohms
A.
B.
C.
D.

7A. ____________________

7B. ____________________

7C. ____________________

7D. ____________________

Score ________

Grade ________

Name ____________________

Date ____________________

Period ____________________

Work Sheet

Activity

Matching 1

1. Voltage
2. Resistance
3. Ampere
4. Current
5. Volt
6. Ohm

A. V
B. O
C. I
D. E
E. A
F. R
G. C
H. Ω

1. ________
2. ________
3. ________
4. ________
5. ________
6. ________

Matching 2

7. Ammeter
8. Voltmeter
9. Ohmmeter
10. Multimeter
11. Must be connected across the component
12. All power must be off in the circuit.
13. Selects mode of operation; what is to be measured
14. Sets maximum value that can be measured

A. Measures resistance in ohms
B. Function switch
C. Measures voltage in volts
D. Voltmeter
E. Ohmmeter
F. Measures current in amps
G. Measures voltage in volts, current in amps, and resistance in ohms
H. Range switch

7. ________
8. ________
9. ________
10. ________
11. ________
12. ________
13. ________
14. ________

15. The basic unit for measuring electrical current is the ______. 15. ____________

16. The force or pressure which causes electrons to move through a circuit is called ______. 16. ____________

17. ______ is the orderly flow of electrons through a circuit. 17. ____________

18. The basic unit of measurement for resistance is the ______. 18. ____________

19. ______ is a measurement of the opposition that a component or circuit offers to current flow. 19. ____________

20. The basic unit for measuring voltage is the ______. 20. ____________

21. In the measurement of an unknown value of voltage, the range switch should be set to its ______ position. 21. ____________

22. What is the purpose of the zero adjust control on a meter?

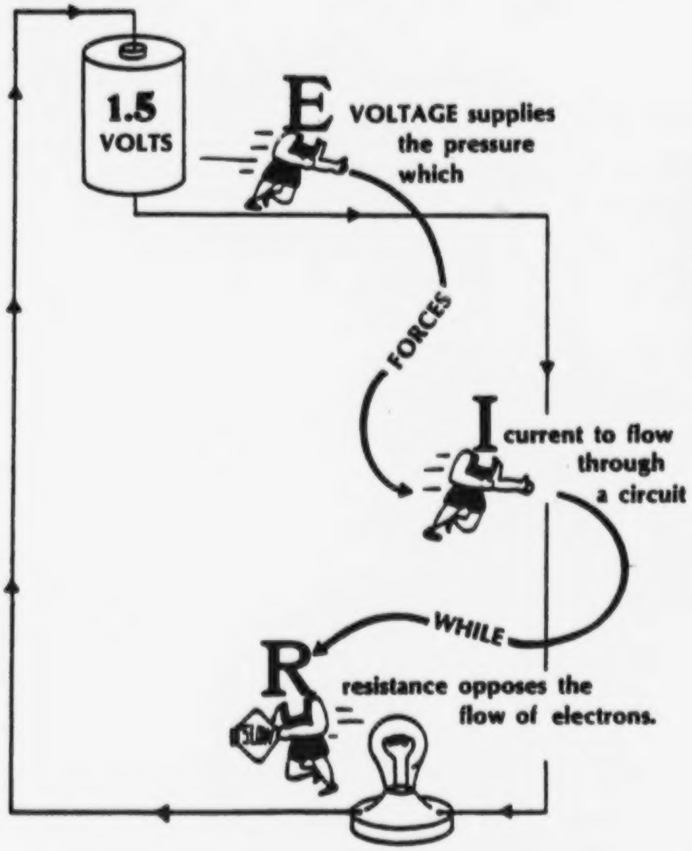
23. Explain what is meant by the expression *observing polarity*.

24. Draw a sketch which illustrates how a meter should be connected to measure voltage.

25. Draw a sketch showing how to connect a meter to measure resistance.

Informational Handout

The Electrical Team


1.5
VOLTS
E
VOLTAGE supplies the pressure which
FORCES
I
current to flow through a circuit
WHILE
R
resistance opposes the flow of electrons.
SLOW

Voltage . . . E
Current . . . I
Resistance . . . R

Units of Measurement

Voltage is measured in the basic unit **Volts (V)**
Current is measured in the basic unit **Amperes (A)**
Resistance is measured in the basic unit **Ohms (Ω)**

Informational Handout

How to Use a Meter to Measure Voltage or Resistance

Set the Function Switch.

Adjust the function switch for the electrical quantity to be measured.

Identify the quantity being measured—DC voltage, AC voltage, or resistance—and select the proper function switch position.

Set the Range Switch.

Caution must be used when setting the range switch. When using the voltage functions, be sure the range switch is set in a high enough position so that you do not peg the meter.

If measuring an unknown value of voltage, set the range switch to the highest position.

In the ohms function, the range position is not critical. Select the position that will move the pointer closest to the middle of the scale.

Zero the Meter.

Be sure to zero the meter so that the measurement will be accurate:

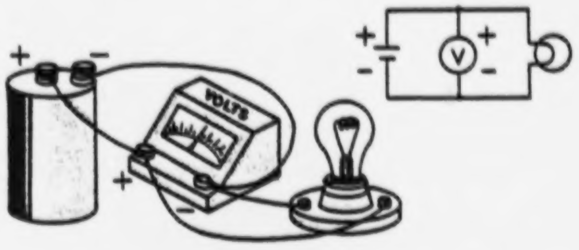
1. If available, adjust the "mechanical zero" so that the meter indicates zero. This adjustment should be made when the meter is off.
2. Zero in for voltage. Turn the meter on and allow enough time for stabilization. Connect the test leads together and use the zero adjust control to set the indicator to zero.
3. Zero in for resistance. After the meter has stabilized, connect the test leads together and adjust for zero resistance with either the zero adjust or ohms adjust (depending on the type of meter). Disconnect the leads and adjust for infinity. The last two steps may have to be repeated to achieve accurate zeroing.

Connect the Meter into the Circuit.

1. *Voltage connection*

   When measuring voltages (AC or DC), you must be sure that the meter is connected in parallel with the circuit.

   Also, be sure to observe polarity when measuring DC voltages. The positive lead of the meter must be connected to the positive side of the circuit. The negative lead must be connected to the negative side of the circuit.



   NOTE: If the reading is below the usable portion on the voltage scale, the range switch may be stepped down one position for a more accurate reading.

2. *Resistance connection*

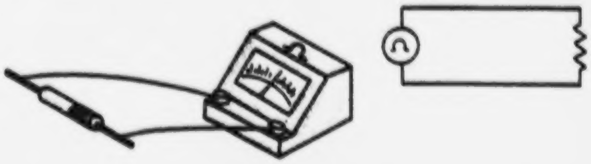
   When measuring resistance, you must be sure that the meter is connected in series with the resistance being measured.

   Be sure that no power is applied to the circuit when you measure resistance.

   The best way to measure the resistance of a resistor is to remove it from the circuit.

   The ohmmeter is a valuable instrument for checking continuity of both components and circuits.

   Polarity need not be observed in this kind of measurement.



NOTE: An accurate reading will be obtained if the needle is close to the middle of the scale. Vary the range switch to locate the position where the pointer moves closest to the center of the scale.

Read the Meter.

Read the value indicated on the meter. Refer to the handout "Procedures in Reading a Meter" for a step-by-step procedure.

Troubleshoot If Necessary.

Common causes of meter malfunctions include the following:

1. Open or damaged test leads
2. Weak or dead batteries
3. Blown fuse or reset
4. Damaged meter circuit
5. Improper meter connection

Be sure to recheck the zero adjustments if you have changed the function or range switch.

Do not touch the metal tips on the test leads when making measurements.

Double-check all connections before turning on the power or taking measurements.

Informational Handout

Procedures in Reading a Meter

The sequence below should be used as a reference guide for reading a meter.

1. **Check the function switch.**
   Determine what quantity is being measured.
2. **Locate the meter scale.**
   Find the scale that matches the quantity that is set on the function switch.
3. **Read the scale.**
   Read the value at which the pointer comes to rest across the scale divisions. Be sure you look directly at the scale to avoid parallax problems.
4. **Check the range switch.**
   Identify the range position and then determine the multiplier.
5. **Multiply the scale reading.**
   Multiply the reading on the scale by the multiplier indicated by the range switch.
6. **Record the reading.**
   When you record the value you have read, be sure to record also the quantity measured in volts, ohms, or amperes.

Answer Key
for Unit 10

	T	F		
	1	2	3	4
1.		■		
2.	■			
3.	■			
4.	■			
5.	■			
6.	■			
7.		■		
8.		■		
9.		■		
10.	■			
11.				■
12.		■		
13.				■
14.	■			
15.		■		
16.				■
17.	2			
18.	5.4			
19.	7.5			
20.	9.7			
21.				
22.				
23.				
24.				
25.				

Glossary Cryptics

1. Meter
2. Voltage
3. Current
4. Ohm
5. Ohmmeter
6. Multimeter
7. Volt
8. Ampere

The Shop Meter

(Answers will vary.)

Reading Meter Scales

1A. ½ inch
1B. 1¾ inches
1C. 2⅞ inches
2A. 7 millimetres
2B. 1.8 centimetres
2C. 2.4 centimetres
3A. 10 volts
3B. 22 volts
3C. 36 volts
3D. 48 volts
4A. 2 volts
4B. 4.5 volts
4C. 7 volts
4D. 9.5 volts
5A. 2.2 volts
5B. 4.6 volts
5C. 7.8 volts
5D. 9.4 volts
6A. 200 ohms
6B. 35 ohms
6C. 9 ohms
6D. 0.75 ohm
7A. 300 ohms
7B. 40 ohms
7C. 11 ohms
7D. 2.5 ohms

Activity

1. D
2. F
3. E
4. C
5. A
6. H
7. F
8. C
9. A
10. G
11. D
12. E
13. B
14. H
15. Ampere
16. Voltage
17. Current
18. Ohm
19. Resistance
20. Volt
21. Highest (maximum)
22. To adjust the meter to 0 on the scale for voltage and current
23. Connecting the meter's negative terminal to negative polarity and the positive terminal to positive polarity
24. (Sketch of a voltmeter connected across the load with power applied to the circuit)
25. (Sketch of an ohmmeter connected across a load with no power applied to the circuit)

Unit 11

Electrical Terms and Symbols

Title of Unit: Electrical Terms and Symbols

Time Allocated: One week

Unit Goal

To integrate with previously taught competencies new competencies that will facilitate immediate recognition of symbols, designations, or terms commonly used in schematic diagrams or technical data sheets

Unit Objectives

The student will be able to do the following:

1. Read and draw a number of technical symbols that represent components commonly used in basic circuits.
2. Identify a variety of letter designations which may accompany a circuit symbol but are not themselves parts of the symbol.
3. Distinguish and interpret a simple schematic diagram.

Evaluation

The student will demonstrate his or her competence in the unit objectives on the basis of performance criteria established by the individual instructors. The criteria may include a combination of written, oral, and laboratory testing procedures.

Instructor's References

Buban, Peter, and Marshall L. Schmitt. *Technical Electricity and Electronics.* New York: McGraw-Hill Book Co., 1976.

Buban, Peter, and Marshall L. Schmitt. *Understanding Electricity and Electronics* (Fourth edition). New York: McGraw-Hill Book Co., 1981.

Duarte, S. R., and R. L. Duarte. *Electronics Assembly and Fabrication Methods.* New York: McGraw-Hill Book Co., 1973, chapters 2–4.

Overview

This unit emphasizes that symbols are a vital part of the technical language used for conveying information in the industrial community.

The unit should be introduced with a discussion of the development and use of graphic illustrations.

The next topics should then deal with basic symbols, letter designations, and organization of the symbols that are used to create a schematic diagram. The schematic diagram should be considered as a vehicle that transmits valuable technical data to the skilled reader.

The student should understand that explanations of new symbols and electrical terms will be given throughout this level.

Suggested Presentation Hints/Methodology

Use this unit as a basic guideline for presenting the curriculum; however, note the following:

1. Teachers often do not instruct on schematic symbols. Such symbols are included in this unit to enhance the student's technical comprehension. Try to associate parts physically with their symbols so that students obtain some immediate familiarity with electronic components. At this point the student may become aware of various markings on the bodies of components, and these identifications or designations can be discussed.
2. Students should be asked to do symbol exercises, if possible, with color pencils, markers, or felt pens.
3. Frequently, symbols are discussed by instructors without mention of standards, recommended drawing practices, application of symbols, and diagram types. These areas involve competencies that are essential in the industrial world and should be emphasized. An inexpensive source of samples of many graphic representations would be a manufacturer's television repair folder.

Supplemental Activities and Demonstrations

The following supplemental activities and demonstrations are suggested for use in presenting the curriculum:

1. A useful activity to introduce schematic symbols to students is for the instructor to pick out an assortment of components for the class to view and have the class name those that actually look like the symbols they represent; the symbols

should be drawn on the chalkboard. Use the chalkboard to list the results and verbally emphasize that many schematic symbols are definitely symbolic pictures.

2. An enjoyable activity is to have students send away for free parts catalogs. Once the students have catalogs, activities may include cutting out pictures of parts and summarizing functions, listing letter designations, and drawing circuit symbols.

Instructional Unit Contents

1. Unit Outline (overhead)
2. Pretest and Post-test (keyed)
3. Technical Glossary
4. Work Sheet (vocabulary)—Word Decoding
5. Work Sheet—Electrical Terms and Symbols
6. Activity
7. Informational Handout (Schematic Symbols)
8. Answer Key for Unit 11

Unit 11

Electrical Terms and Symbols

(Lecture Outline)

A. Electrical Circuit Diagrams
   1. Schematic symbols
   2. Letter designations
   3. Schematic diagrams

B. Electrical Terms

Test number ____________

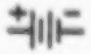
Examination for Unit 11

Electrical Terms and Symbols

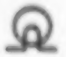
Write your answers to the questions on the answer sheet. Fill in the box that corresponds to the correct answer to the question. Each question has only one correct answer.

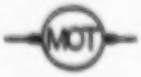
1. Components are shown as graphic symbols on schematic diagrams. (T-F)
2. The dot symbol on a schematic diagram is used to show that wires are electrically connected to each other. (T-F)
3. Abbreviations or letter designations are used to simplify component identification. (T-F)
4. A typical reference designation uses a number/letter code such as 3_R (to designate resistor No. 3). (T-F)
5. Schematic symbols are used to illustrate electronic terms. (T-F)

Identify the schematic symbols drawn below:

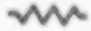
6.


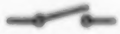
____

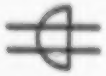
7.

____

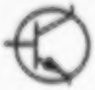
8.


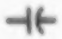
____

9.

____

10.

____

11.

____

12.

____

13.

____

Identify the abbreviations or letter designations listed below:

14. Ω ______________________________

15. T ______________________________

16. DC ______________________________

17. L ______________________________

18. Q ______________________________

19. D ______________________________

20. GND ______________________________

Technical Glossary

Abbreviation—The expression of a word or term, in shortened form, usually by using representative letters. Example: The term *direct current* is abbreviated with the letters DC.

Component—An electronic part.

Connection—The junction or joining point of several conductors or components in an electrical circuit.

Electrical term—A word or phrase which describes an electrical quantity, unit of measurement, component, or electrical action.

Letter identification—A letter used to designate a particular type of electronic component. For example, the letter identification for a capacitor is C.

Numerical value—The rating or value of a component expressed in its unit of measurement. The numerical value of a 1,000-ohm resistor, for example, can be expressed as 1,000 or 1k.

Reference designation—The symbol used to represent components in a circuit diagram. The reference designation combines a letter identification and a subscript to identify one particular component. The designation for resistor 3 on a schematic diagram would be R_3.

Schematic diagram—A special type of drawing used in electronics to represent circuit components and connections. This type of diagram uses simplified symbols to show electrical connections but does not show the physical layout or part structure.

Schematic symbol—A symbolic representation used to depict an electronic component; often referred to as a graphic symbol.

Subscripts—Small identifying numbers or letters written slightly to the right of and below the quantity being identified. For example, in the expression R_3, 3 is the subscript.

Score ________ Name ____________________

Grade ________ Date ____________________

Period ____________________

Work Sheet

Word Decoding

The words below have little meaning until they are decoded. Each letter actually represents another letter of the alphabet. The example will get you started in decoding the other scrambled words listed on the work sheet.

Example:

A. HAHJSUDJDSN A. ELECTRICITY

1. SHUZ 1. ____________________

2. TNZKXA 2. ____________________

3. JXZWXYHYS 3. ____________________

4. JXYYHJSDXY 4. ____________________

5. TRKTJUDWST 5. ____________________

6. LKKUHQDLSDXY 6. ____________________

7. YRZHUDJLA QLARH 7. ____________________

8. TJEHZLSDJ IDLFULZ 8. ____________________

9. AHSSHU DIHYSDGDJLSDXY 9. ____________________

10. UHGHUHYJH IHTDFYLSDXY 10. ____________________

Score ________

Grade ________

Name ____________________

Date ____________________

Period ____________________

Work Sheet

Electrical Terms and Symbols

A. Draw the correct schematic symbols for the following electronic components:

________ 1. Cell

________ 2. Ammeter

________ 3. Fixed value capacitor

________ 4. Iron core transformer

________ 5. Fuse

________ 6. Incandescent lamp

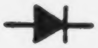
________ 7. Single-pole, single-throw switch

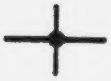
________ 8. DC motor

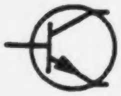
________ 9. Thermocouple

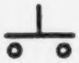
________ 10. Adjustable resistor

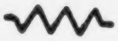
B. Identify the following graphic symbols:

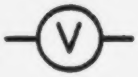
11.  ____________________

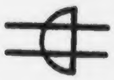
12.  ____________________

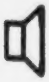
13.  ____________________

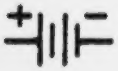
14.  ____________________

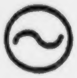
15.  ____________________

16.  ____________________

17.  ____________________

18.  ____________________

19.  ____________________

20.  ____________________

C. Give the letter designation or abbreviation for the following:

21. Current __________
22. Ground __________
23. Milli- __________
24. Ohm __________
25. Positive __________
26. Capacitor __________
27. Battery __________
28. Switch __________
29. Light-emitting diode __________
30. Resistor __________

D. Identify the following letter designations or abbreviations:

31. L ______________________________
32. DC ______________________________
33. DPDT ______________________________
34. Q ______________________________
35. D ______________________________
36. LP ______________________________
37. T ______________________________
38. A ______________________________
39. E ______________________________
40. k ______________________________

Score ________

Grade ________

Name ______________________

Date ______________________

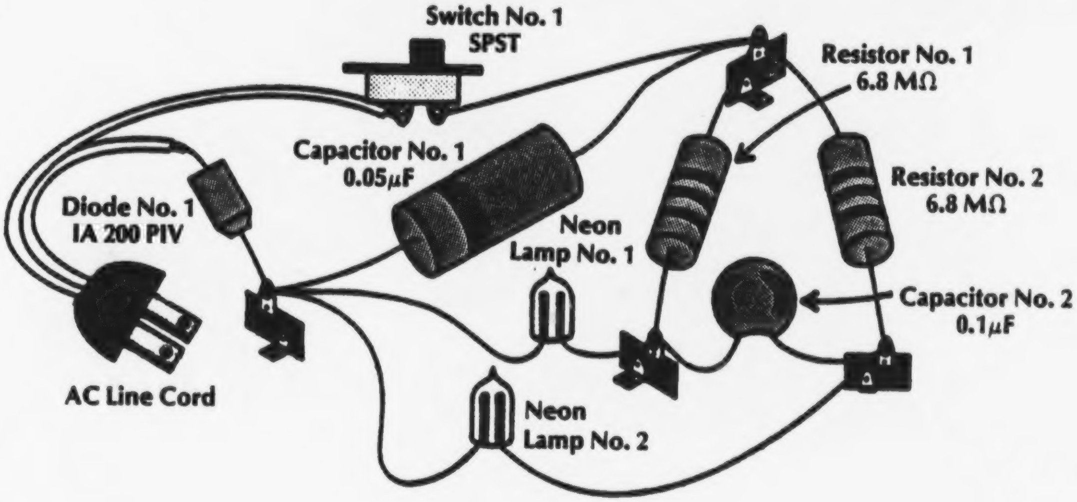
Period ______________________

Work Sheet

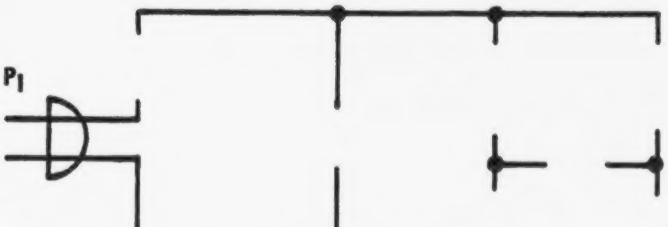
Activity

Presented below is a pictorial diagram of a blinking lamp or night-light circuit. Each part is accompanied by necessary descriptive information. A schematic diagram can also be used to represent this same circuit. In a schematic diagram, symbols are used to represent the various components, and letter designations are used to identify parts and provide information.

Study the pictorial diagram and then complete the schematic diagram by drawing the correct symbols in their proper locations. Include letter designations and electrical units on your diagram.


Switch No. 1
SPST
Resistor No. 1
6.8 MΩ
Capacitor No. 1
0.05μF
Resistor No. 2
6.8 MΩ
Diode No. 1
IA 200 PIV
Neon
Lamp No. 1
Capacitor No. 2
0.1μF
AC Line Cord
Neon
Lamp No. 2

PICTORIAL

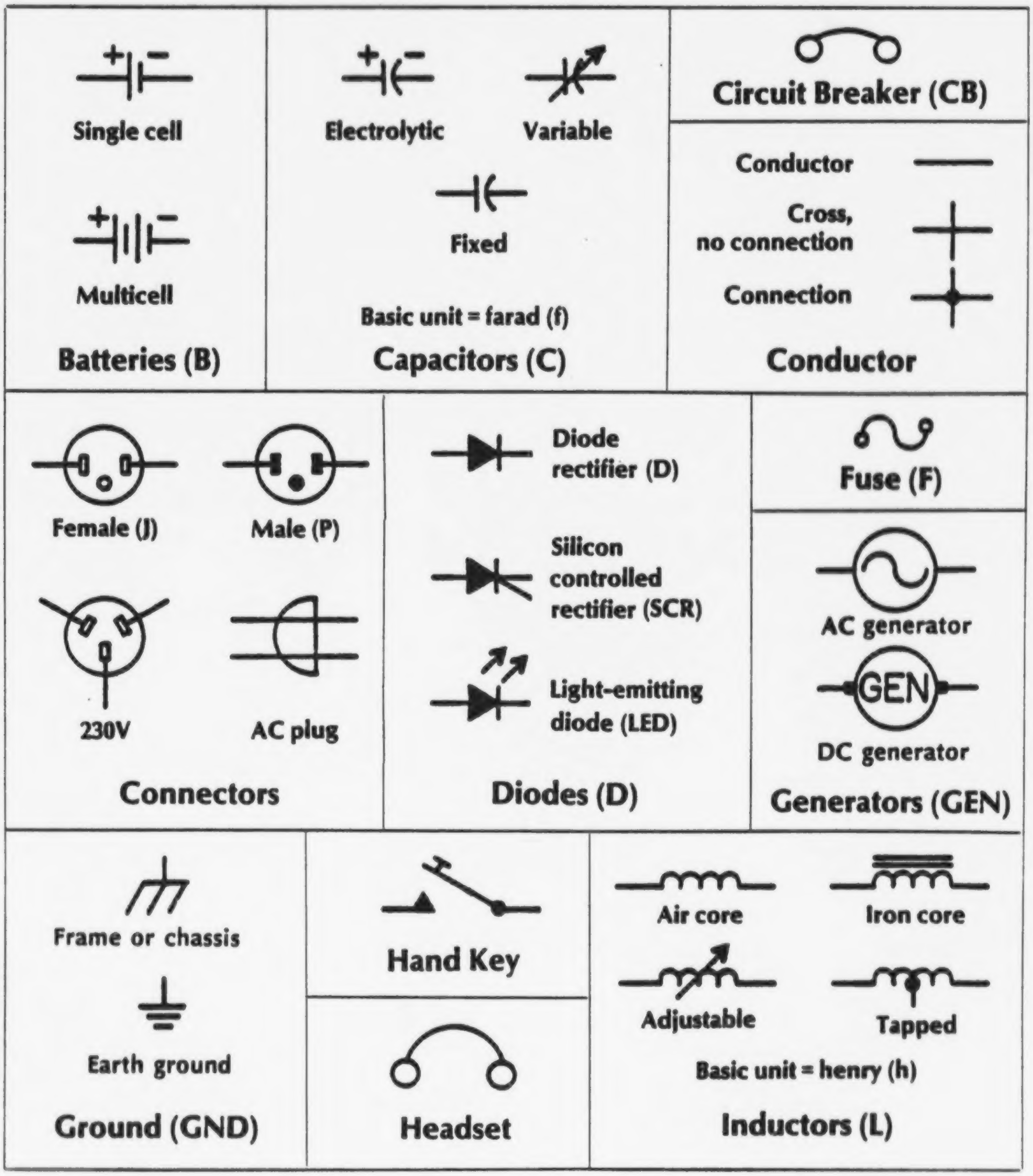


SCHEMATIC

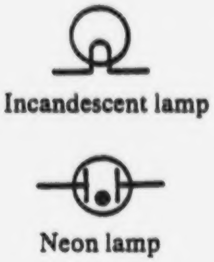
Informational Handout

Schematic Symbols

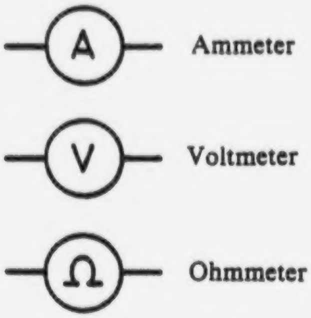
Illustrated below are the schematic symbols that are commonly used in depicting electrical and electronic devices. Currently accepted letter designations and unit abbreviations are also provided.



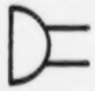
Single cell
Multicell
Batteries (B)
Electrolytic
Variable
Fixed
Basic unit = farad (f)
Capacitors (C)
Circuit Breaker (CB)
Conductor
Cross, no connection
Connection
Conductor
Female (J)
Male (P)
230V
AC plug
Connectors
Diode rectifier (D)
Silicon controlled rectifier (SCR)
Light-emitting diode (LED)
Diodes (D)
Fuse (F)
AC generator
GEN
DC generator
Generators (GEN)
Frame or chassis
Earth ground
Ground (GND)
Hand Key
Headset
Air core
Iron core
Adjustable
Tapped
Basic unit = henry (h)
Inductors (L)


Incandescent lamp
Neon lamp

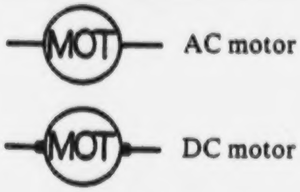
Lamps (LP)


Ammeter
Voltmeter
Ohmmeter

Meters (M)



Microphone

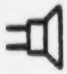

AC motor
DC motor

Motors (MOT)

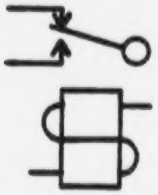
+ Positive

- Negative

Polarity

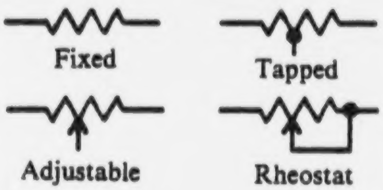


Speaker (Spkr)



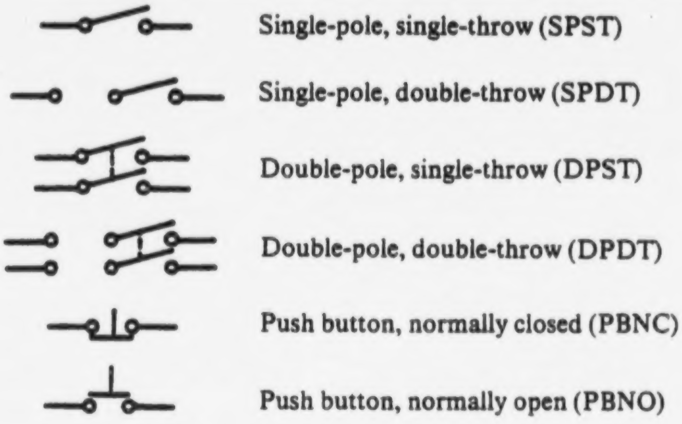
Single-pole, double-throw

Relay (K)

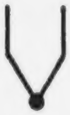

Fixed
Tapped
Adjustable
Rheostat

Basic unit = ohm (Ω)

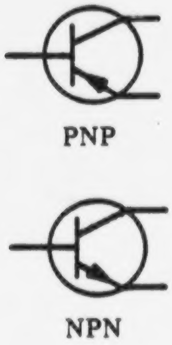
Resistors (R)


Single-pole, single-throw (SPST)
Single-pole, double-throw (SPDT)
Double-pole, single-throw (DPST)
Double-pole, double-throw (DPDT)
Push button, normally closed (PBNC)
Push button, normally open (PBNO)

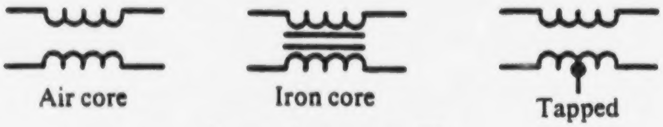
Switches (S)



Thermocouple (TC)



Transistors (Q)


Air core
Iron core
Tapped

Transformers (T)

The following are standard abbreviations that have been adopted by the Institute of Electrical and Electronics Engineers (IEEE):

Alternating current	AC
Ampere or amp	A
Capacitance	C
Current	I
Cycles per second	cps
Direct current	DC
Electromotive force	EMF
Farad	F
Ground	GND
Henry	h
Hertz	Hz
Inductance	L
Input	IN
Kilo-	k
Kilowatt-hour	kwh
Mega-	M
Micro-	μ
Micro-micro	μμ
Milli-	m
Nano-	n
Negative	−
Ohm	Ω
Output	OUT
Pico-	p
Positive	+
Power	P
Resistance	R
Second	s
Sine wave	∼
Volt	V
Voltage	E
Watt	W

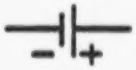
Answer Key
for Unit 11

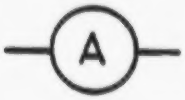
	T	F		
	1	2	3	4
1.	■			
2.	■			
3.	■			
4.		■		
5.		■		
6.	Battery			
7.	Lamp			
8.	Motor (DC)			
9.	Resistor			
10.	SPST Switch			
11.	Plug (AC)			
12.	Transistor (NPN)			
13.	Capacitor			
14.	Ohm			
15.	Transformer			
16.	Direct current			
17.	Inductor			
18.	Transistor			
19.	Diode			
20.	Ground			
21.				
22.				
23.				
24.				
25.				

Word Decoding

1. Term
2. Symbol
3. Component
4. Connection
5. Subscripts
6. Abbreviation
7. Numerical value
8. Schematic diagram
9. Letter identification
10. Reference designation

Electrical Terms and Symbols

1.


2.


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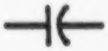

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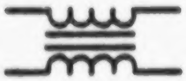
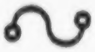


5.


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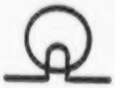

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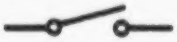

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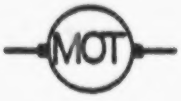
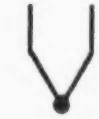
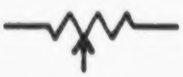


9.


10.


11. Diode
12. Connection
13. Transistor (NPN)
14. Push-button switch N.O.
15. Fixed resistor
16. Voltmeter
17. AC plug
18. Speaker
19. Battery
20. AC generator
21. I
22. GND
23. m
24. Ω
25. +
26. C
27. B
28. S
29. LED
30. R
31. Inductor
32. Direct current
33. Double-pole, double-throw
34. Transistor
35. Diode
36. Lamp
37. Transformer
38. Ampere
39. Voltage
40. Kilo-

Activity

(Answers will vary.)

Unit 12

Components, Switches, and Circuits

Title of Unit: Components, Switches, and Circuits

Time Allocated: Two weeks

Unit Goal

To instill in students competence in identifying basic components and circuits, including knowledge of switches, types of circuit configurations, and recognition of simple circuit malfunctions

Unit Objectives

The student will be able to do the following:

1. Identify and explain the general technical functions of the following common components: resistor, inductor, capacitor, switch, speaker, xenon flashtube, neon lamp, transformer, and diode.
2. Demonstrate basic circuit construction skills by physically manipulating electrical devices into either series, parallel, or combination circuit configurations.
3. Perform basic inspection and troubleshooting steps to locate a defect or abnormal condition in a circuit.

Evaluation

The student will demonstrate his or her competence in the unit objectives on the basis of performance criteria established by the individual instructors. These criteria may include a combination of written, oral, and laboratory testing procedures.

Instructor's References

Buban, Peter, and Marshall L. Schmitt. *Technical Electricity and Electronics.* New York: McGraw-Hill Book Co., 1976.

Duarte, S. R., and R. L. Duarte. *Electronics Assembly and Fabrication Methods.* New York: McGraw-Hill Book Co., 1973, chapters 2, 4, 11, and 12.

Overview

This unit is designed to provide the student with sufficient technical knowledge to be able to construct a kit or project.

The first unit topic is oriented to teaching component identification, with specific emphasis on the common components that are encountered in typical beginning-type projects or kits.

Next, circuit-controlling devices are discussed, because this topic is directly applicable to many aspects of both project and/or laboratory circuit work. Instructors should allow students the time to examine the switches thoroughly.

An explanation of simple circuit configurations is included as a means to discuss and discover the electrical characteristics of various kinds of circuits. The study of basic circuits will help formulate in the student's mind a technical reference point of what constitutes normal circuit behavior.

Suggested Presentation Hints/Methodology

Use this unit as a basic guideline for presenting the curriculum; however, note the following:

1. Investigate with the class a variety of components that might be encountered when building a simple project. Place a component on top of the stage plate of an overhead projector and examine its size and shape. Discuss the general purpose, special properties, value determination/codes, and other essential data.
2. Stress during a presentation that many types of switches are used to control electricity and that each has unique characteristics which may offer certain advantages or disadvantages. Try to collect and display switches of different physical conformation and function. Explain that, in its simplest form, a switch is still merely a device to open or close a circuit. It may be helpful to concentrate on the specific symbol when describing a certain type of switch, because exposure to the symbol allows the student an opportunity to examine the way in which the switch operates in the circuit.
3. Have the class review the essential parts of a circuit and initiate a discussion on devices in series and parallel. The relationships of E and I for these networks are important concepts to establish.

Supplemental Activities and Demonstrations

The following supplemental activities and demonstrations are suggested for use in presenting the curriculum:

1. Training systems sometimes miss the point in respect to switches and the method of connecting them to control a circuit. Perhaps this method and the idea of connecting devices in series and parallel should be explored further in a laboratory-type performance test. Buzzers and switches mounted on a board with exposed terminals can serve as an excellent evaluation tool when students are asked to create systematically basic circuit configurations. After the student builds each circuit, sign the student off and let him or her go on to a more complex configuration.
2. The various abnormal circuit conditions can be illustrated through the use of several experiments. The demonstration should be controlled, but the students will be impressed if a component or two are burned up while they are watching the activity. Help the students to develop a detective-style approach to solving problems in circuits: Observe symptoms, look for the clues, logically deduce the malfunction, and then repair and check.

Instructional Contents:

1. Unit Outline (overhead)
2. Pretest and Post-test (keyed)
3. Technical Glossary
4. Work Sheet (vocabulary)—Spelling Puzzle
5. Work Sheet—Component Identification
6. Activity
7. Informational Handout (Basic Electronic Components Used in Project Construction)
8. Informational Handout (Normal and Abnormal Circuits)
9. Answer Key for Unit 12

Unit 12

Components, Switches, and Circuits

(Lecture Outline)

A. Identification of Common Components
   1. Physical characteristics
   2. Value determination or identification codes
   3. Purpose and/or usage

B. Circuit-Controlling Devices
   1. Switches used as control devices
   2. Types of switches
   3. Switch circuits

C. Basic Electrical Circuits
   1. Series circuits
   2. Parallel circuits
   3. Series-parallel circuitry

D. Switches in Series and Parallel Circuits
   1. Series switching circuits
   2. Parallel switching circuits

E. Normal and Abnormal Circuits
   1. Closed circuit
   2. Open circuit
   3. Shorted circuit

Test number ________

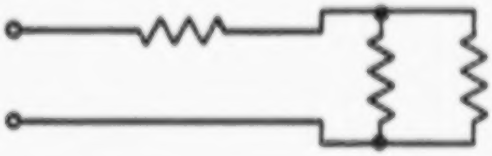
Examination for Unit 12

Components, Switches, and Circuits

Write your answers to the questions on the answer sheet. Fill in the box that corresponds to the correct answer to the question. Each question has only one correct answer.

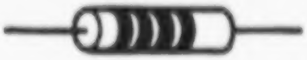
1. Resistor values are given in ohms. (T-F)
2. A potentiometer is a variable resistor which contains three terminals and has a movable center shaft. (T-F)
3. A transistor can be used to step up or step down voltage. (T-F)
4. Abnormal circuits commonly contain either a short or an open condition. (T-F)
5. Capacitors will allow current to flow in only one direction through a circuit. (T-F)
6. An open circuit provides an easy path for current flow. (T-F)
7. A switch is used either to open or close a circuit or to direct current flow through the circuit. (T-F)
8. A parallel circuit contains only one path for current flow. (T-F)
9. Capacitors are rated in units of microfarads or picofarads. (T-F)
10. Switches are always connected in series with the current path they are controlling. (T-F)
11. The abbreviation PBNO means:
    1. Pull back, now open
    2. Push-button normally open
    3. Push-button not open
    4. Push back naturally open
12. An accidental circuit connection which causes excessive current and possible circuit damage is called which of the following?
    1. Open
    2. Branch
    3. Short
    4. Closed
13. A circuit which contains more than one path for current flow is known as a(n):
    1. Parallel circuit
    2. Series circuit
    3. Abnormal circuit
    4. Normal circuit
14. Which of the following switches is capable of controlling two separate circuits simultaneously?
    1. SPST
    2. PBNO
    3. DPNT
    4. DPST

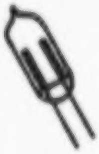
15. Classify the circuit shown below.



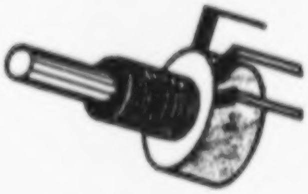
1. Parallel circuit
2. Series circuit
3. Compound circuit
4. Series-parallel circuit

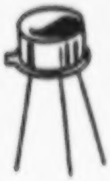
Identify the components shown below:

16.  ________________

17.  ________________

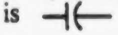
18. ________________

19.  ________________

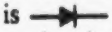
20.  ________________

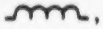
Technical Glossary

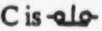
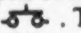
Abnormal circuit—A circuit which is not functioning properly. An abnormal circuit is generally open (a broken current path) or shorted (an undesired current path).

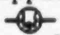
Capacitor—An electronic component made up of two metal plates separated by an insulator. Capacitors have the ability to store charges. The symbol for the capacitor is , and the letter symbol is C.

Closed circuit—Any electrical circuit which contains a complete path for current flow from the negative terminal of the source to the positive terminal.

Diode—A semiconductor device which acts as a one-way valve to current flow. The symbol for the diode is , and the letter symbol is D.

Inductor—An electronic component made by wrapping a coil of wire around an air or iron core. An inductor opposes any change in current flow. The symbol for the inductor is , and the letter symbol is L.

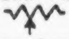
Momentary switch—A type of switch that is operated by pushing on a lever or button. Once the pressure is removed, the switch is turned off. Momentary-contact switches are often push-button-type switches and are available as either normally open or normally closed devices. The symbol for the PBNC is , and the symbol for the PBNO is . The letter symbol is S.

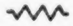
Neon lamp—A glow lamp which contains neon gas. When a voltage of approximately 55 volts is applied to the lamp, the neon gas ionizes and glows orange. The symbol for a neon lamp is , and the letter symbol is LP.

Normal circuit—A circuit which is functioning properly and provides a complete path for current flow.

Open circuit—A circuit which contains a break or gap in the current path. The break will stop the circuit from operating.

Parallel circuit—A circuit which contains two or more paths for current flow; sometimes referred to as a shunt or branch circuit.

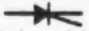
Potentiometer—A variable resistor commonly used for volume, sensitivity, or speed control on many projects. The symbol for the potentiometer is , and the letter symbol is R.

Resistor—A simple, yet important, electronic component made from either carbon, wire, or metal oxide and used to provide a specific opposition to current flow. The symbol for the resistor is , and the letter symbol is R.

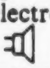
Series circuit—A circuit which allows only one path for current flow. Components connected in series are joined in a line, one after the other.

Series-parallel circuit—A circuit consisting of one or more series and parallel paths. Series-parallel circuits are often called combination circuits.

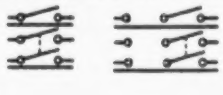
Shorted circuit—A circuit which contains a low-resistance path between two points (power supply terminals, line, and so forth). This condition causes excessively high current flow and possible circuit damage. A shorted circuit is usually caused by an accidental connection.

Silicon-controlled rectifier—A three-terminal electronic component belonging to the "diode family," with the ability to switch fairly large currents on and off electronically. The symbol for the silicon-controlled rectifier is , and the letter symbol is SCR.

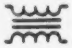
Slide switch—A style of switch in which a bar of metal is made to move or slide and make contact between two points—either opening or closing the circuit. Slide switches are generally inexpensive.

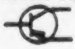
Speaker—An electronic component which can convert electrical signals into sound. The symbol for a speaker is , and the letter symbol is SPKR.

Switch—An electronic component used to control or direct current flow. Switches are commonly used to open or close a circuit path. Switches are available in many styles and configurations, such as push-button; slide; toggle; micro; rotary; single-pole, single-throw; and double-pole, double-throw. The letter symbol for the switch is S. Other symbols are as follows: SPST, SPDT, DPST, and DPDT.



Toggle switch—A common switch style which uses a "snap action" principle to move a set of contacts from one side of the switch to the other for opening or closing the circuit.

Transformer—An electronic component able to step up (increase) or step down (decrease) an AC voltage. The symbol for the transformer is  , and the letter symbol is T.

Transistor—An electronic component which can be used to amplify an electrical signal. Transistors are also used as high-speed switches. The symbol for the transistor is  , and the letter symbol is Q.

Xenon flashtube—A special-purpose lamp that is capable of producing a brilliant flash of light. Xenon flashtubes are found in strobe lights and photographic strobes.

Score ________ Name ____________________

Grade ________ Date ____________________

Period ____________________

Work Sheet

Spelling Puzzle

Write the correctly spelled word in the space at the right, as shown in the example below.

A. (ampmeter) (ammeter) (ameter) A. ammeter

1. (curcuit) (sircuit) (circuit) 1. ____________

2. (diode) (dyode) (diold) 2. ____________

3. (siries) (ceries) (series) 3. ____________

4. (tagole) (toggle) (toggel) 4. ____________

5. (speaker) (speeker) (speker) 5. ____________

6. (switch) (swich) (swit) 6. ____________

7. (parelel) (parallel) (parrellel) 7. ____________

8. (silicon) (silecon) (silacon) 8. ____________

9. (capasetor) (capaciter) (capacitor) 9. ____________

10. (normel) (normol) (normal) 10. ____________

11. (inducter) (inductor) (enductor) 11. ____________

12. (momentary) (monantary) (momintary) 12. ____________

13. (tramsister) (transister) (transistor) 13. ____________

14. (rectifire) (rectifier) (recktifier) 14. ____________

15. (potenteometer) (potentimeter) (potentiometer) 15. ____________

Score ________ Name ____________________

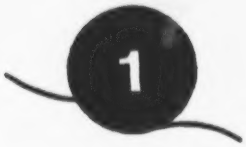
Grade ________ Date ____________________

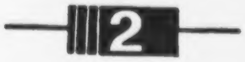
Period ____________________

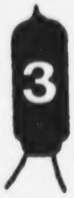
Work Sheet

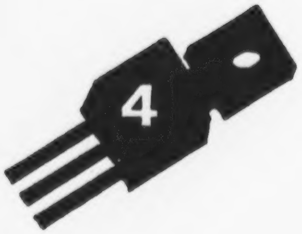
Component Identification

Identify the components in the drawings shown below.







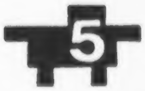


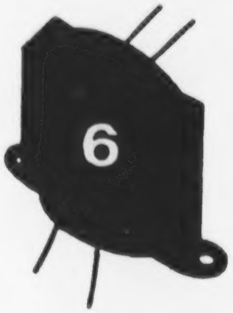
1. ____________________

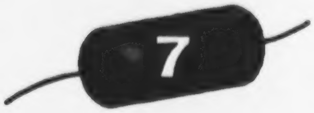
2. ____________________

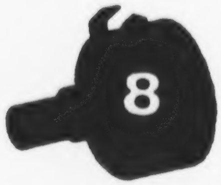
3. ____________________

4. ____________________







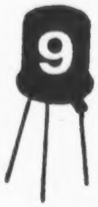


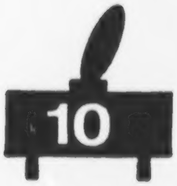
5. ____________________

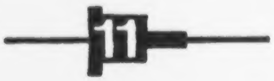
6. ____________________

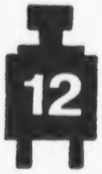
7. ____________________

8. ____________________









9. ____________________

10. ____________________

11. ____________________

12. ____________________

Score ________ Name ______________________

Grade ________ Date ______________________

Period ______________________

Work Sheet

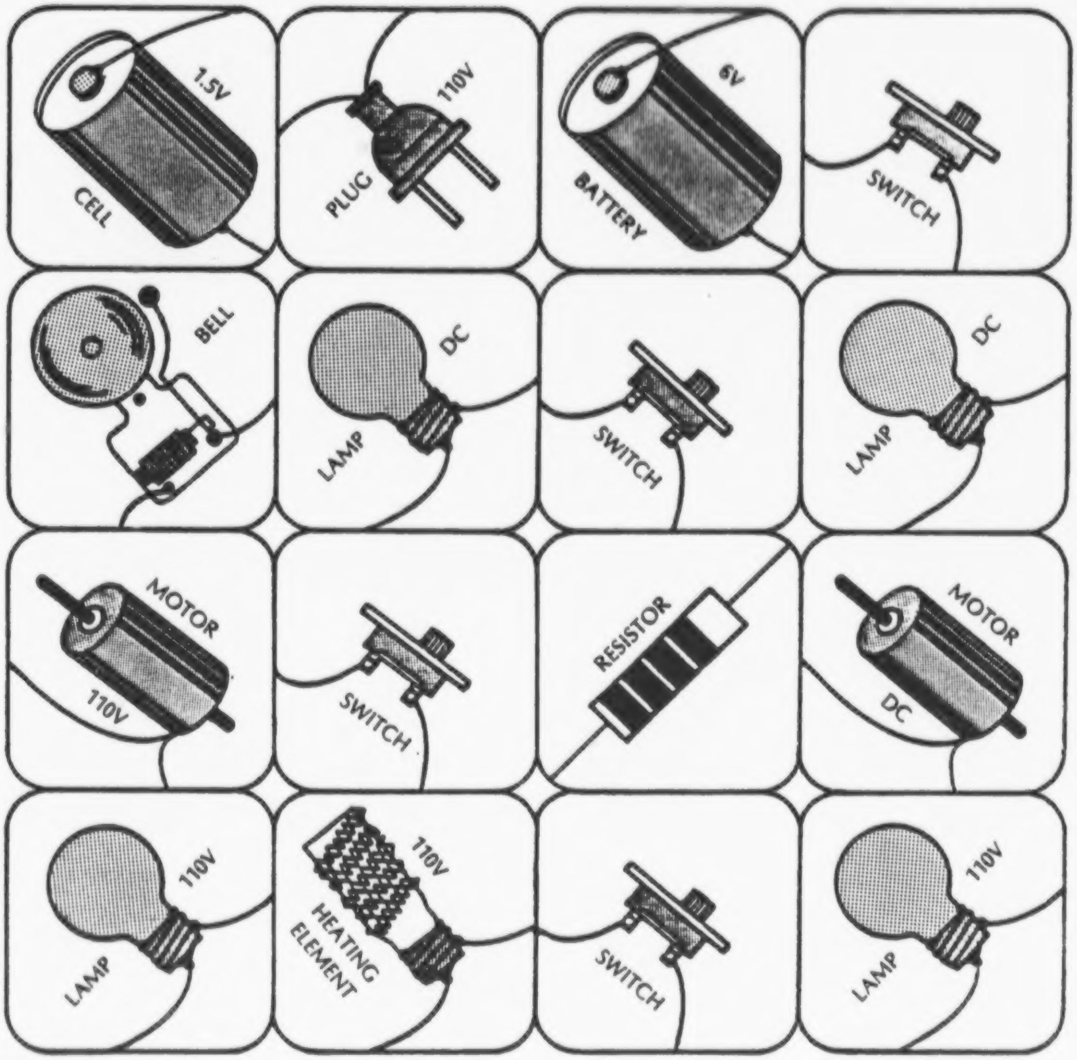
Activity

Use the cutouts provided on the following page to construct the circuits described below. Arrange the cutouts to form series, parallel, and series-parallel circuits. Draw in interconnecting lines to represent conductors. Be sure that each problem fulfills the four requirements for a complete electrical circuit: supply, control, load, and conductor.

1. Construct a series circuit using a 1.5V cell to supply power, an SPST switch to control current flow, and two lamps as load devices.

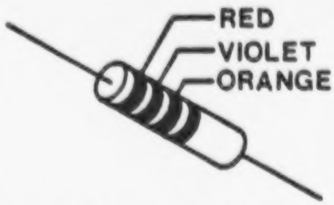
2. Design a parallel circuit with a 110V source and an SPST switch as an on-off control. The circuit is to contain three branches, and each branch will operate a different load device.

3. Assemble a series-parallel circuit consisting of two series loads and two parallel loads. The circuit operates on 6V DC; contains an SPST switch, which will deenergize the total circuit; and an SPST switch to control one of the parallel loads. Use any four appropriate load devices.

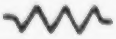

CELL
1.5V
PLUG
110V
BATTERY
6V
SWITCH
BELL
LAMP
DC
SWITCH
LAMP
DC
MOTOR
110V
SWITCH
RESISTOR
MOTOR
DC
LAMP
110V
HEATING ELEMENT
110V
SWITCH
LAMP
110V

Informational Handout

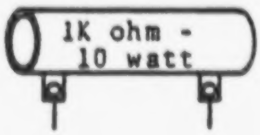
Basic Electronic Components Used in Project Construction


RED
VIOLET
ORANGE

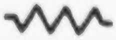
Carbon Composition Resistor

Symbol: 

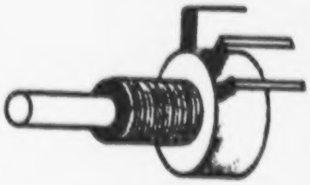
Letter designation: R


1K ohm -
10 watt

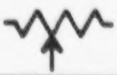
Power Resistor

Symbol: 

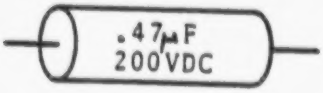
Letter designation: R



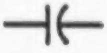
Potentiometer

Symbol: 

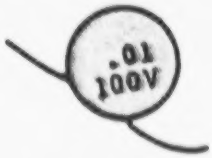
Letter designation: R


.47μF
200VDC

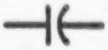
Tubular Capacitor

Symbol: 

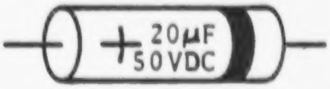
Letter designation: C



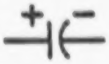
Ceramic or Disc Capacitor

Symbol: 

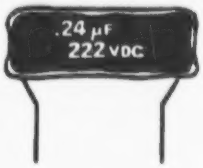
Letter designation: C



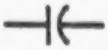
Electrolytic Capacitor

Symbol: 

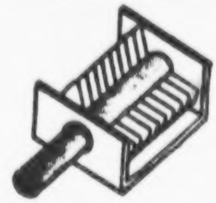
Letter designation: C


.24 μF
222 VDC

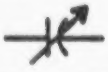
Mylar Capacitor

Symbol: 

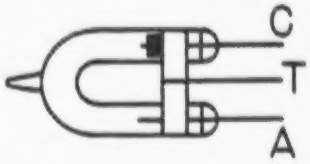
Letter designation: C



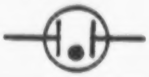
Variable Capacitor

Symbol: 

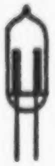
Letter designation: C



Xenon Flashtube

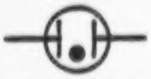
Symbol: 

Letter designation: LP

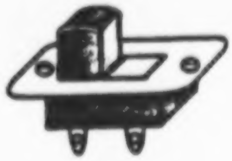


Neon Lamp

Symbol:

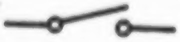


Letter designation: LP

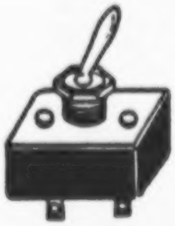


SPST Slide Switch

Symbol:

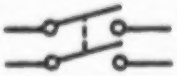


Letter designation: S

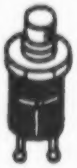


DPST Toggle Switch

Symbol:

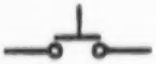


Letter designation: S

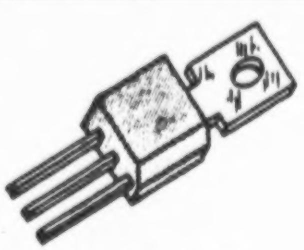


N.O. Push-Button Switch

Symbol:

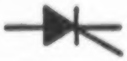


Letter designation: S

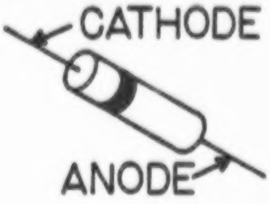


Silicon Controlled Rectifier

Symbol:

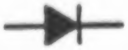


Letter designation: SCR

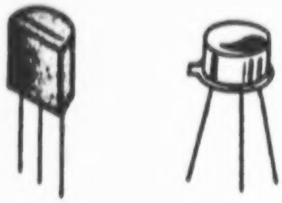


Semiconductor Diode

Symbol:

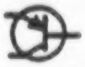


Letter designation: D

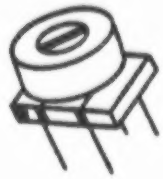


Transistor

Symbol:

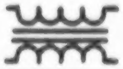


Letter designation: Q

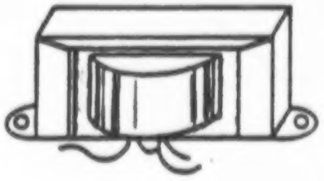


Trigger Transformer

Symbol:

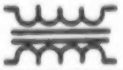


Letter designation: T

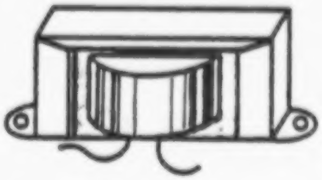
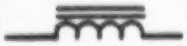
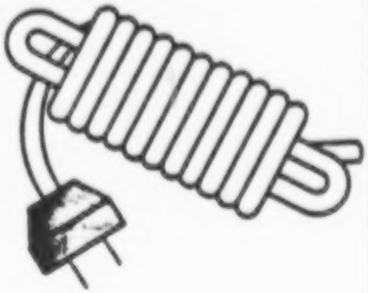
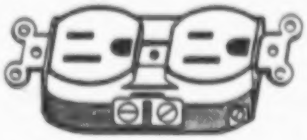
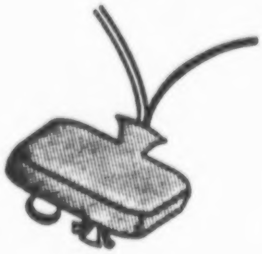
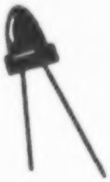
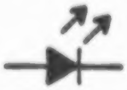
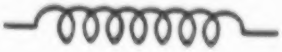
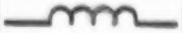
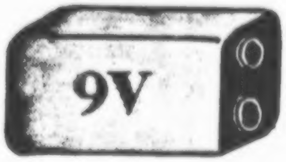
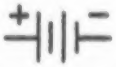
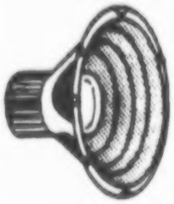
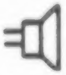
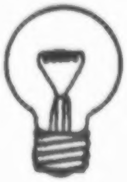
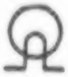


Transformer

Symbol:



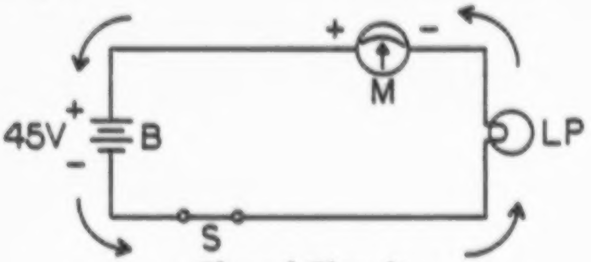
Letter designation: T

 **Inductor (Coil)** Symbol:  Letter designation: L	 **AC Line Cord**	 **Electrical Outlet**
 **Battery Connector**	 **Light-Emitting Diode** Symbol:  Letter designation: D	 **Inductor (Coil)** Symbol:  Letter designation: L
 **Battery** Symbol:  Letter designation: B	 **Speaker** Symbol:  Letter designation: SPKR	 **Incandescent Lamp** Symbol:  Letter designation: LP

Informational Handout

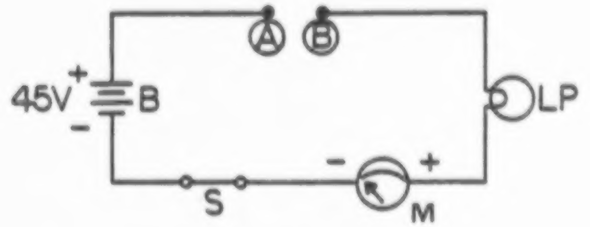
Normal and Abnormal Circuits

The schematic below shows a typical circuit in which a DC voltage, E, forces the current, I, through a load device. This circuit is called a closed circuit because all of the circuit parts are connected in a manner which allows an unbroken path for the flow of electrons. The load device (lamp) will operate properly, and the circuit is considered normal in terms of operation.



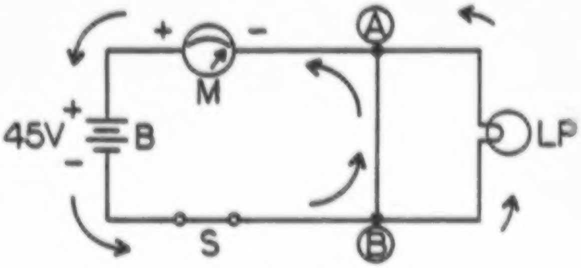
Closed Circuit

The next circuit has been broken open between points A and B; hence, the term *open circuit*. Since electrons cannot jump the gap from A to B, *no current* can flow from the battery to the load device, and, thus, the circuit is considered disabled. Closing a circuit usually means turning it on or placing it in operation; opening a circuit generally means turning it off. The circuit may also be turned off by an abnormal circuit condition. Many times, an open circuit is created by a wire or component breaking in half and stopping the current flow.



Open Circuit

The last schematic indicates that a conductor has been accidently connected across the circuit from A to B. Because of the lower resistance of the path between A and B, most of the current, I, flows through this path, robbing the load device of its proper current flow. This condition is often spoken of by technical people as "electricity taking the path of least resistance." Most, but not all, of the current flows through this abnormal path; however, because of the shorter route taken by the current in this case, path A to path B, this abnormal circuit is called a *short circuit*. Generally, short circuits are unintentional; they are caused either by accident or by mistakes in wiring. A wire or piece of metal that has fallen onto an electrical circuit can cause a short circuit. Short circuits must be avoided because the large currents they create can cause damage to power sources and circuit components. A portion of a circuit as well as the whole circuit may become short-circuited and create dangerous situations.



Short Circuit

Review

A typical normal circuit is one which operates properly and usually contains the following:

1. A source of E and I (supply)
2. A device to turn the circuit on or off (control)
3. A path for electricity to travel through (conductor)
4. A device to operate (load)

When a circuit does not operate right, it is said to be abnormal. Two main types of defective or abnormal circuits that must often be repaired are as follows:

1. Open circuits
2. Shorted circuits

A repairperson is often asked to fix electrical products. The process of determining what is wrong is called troubleshooting. To troubleshoot quickly requires that the repairperson know the characteristics of abnormal circuits.

Answer Key
for Unit 12

	T	F		
	1	2	3	4
1.	■			
2.	■			
3.		■		
4.	■			
5.		■		
6.		■		
7.	■			
8.		■		
9.	■			
10.	■			
11.		■		
12.			■	
13.	■			
14.				■
15.				■
16.	Resistor			
17.	Neon lamp			
18.	Disc capacitor			
19.	Potentiometer			
20.	Transistor			
21.				
22.				
23.				
24.				
25.				

Spelling Puzzle

1. Circuit
2. Diode
3. Series
4. Toggle
5. Speaker
6. Switch
7. Parallel
8. Silicon
9. Capacitor
10. Normal
11. Inductor
12. Momentary
13. Transistor
14. Rectifier
15. Potentiometer

Component Identification

1. Disc capacitor
2. Carbon composition resistor
3. Neon lamp
4. Silicon controlled rectifier
5. Slide switch
6. Transformer
7. Tubular capacitor
8. Potentiometer or rheostat
9. Transistor
10. SPST toggle switch
11. Diode
12. Push-button switch

Activity

(Answers will vary.)

Unit 13

Resistance and Resistors

Title of Unit: Resistance and Resistors

Time Allocated: One week

Unit Goal

To help the student grasp the theory and application of resistance and the nature and characteristics of resistive devices or components

Unit Objectives

The student will be able to do the following:

1. Define the term, symbol, and unit of measurement for resistance and list the four factors which determine the resistance of wire.
2. Name the three common types of resistors and the two coding systems used for indicating ohmic values.
3. Identify the color coded value of any typical resistor, including the tolerance percentage and the usable tolerance range.

Evaluation

The student will demonstrate his or her competence in the unit objectives on the basis of performance criteria established by the individual instructors. The criteria may include a combination of written, oral, and laboratory testing procedures.

Instructor's Reference

Mileaf, Harry. *Electricity One-Seven.* Rochelle Park, N.J.: Hayden Book Company, Inc., 1976, Chapter 2.

Overview

The goal of this unit is to broaden the student's technical competencies and knowledge of resistance.

Electrical resistance should be defined as the opposition to current flow, and the instructor should indicate that all materials contain this quality. The thought that resistance might be a desired factor should be explored, as well as the traditionally negative aspect of circuit resistance.

The next topic should include a discussion about wire resistors and the fact that these devices are especially suited to handling current even though they may have an appreciable amount of resistance.

The final topic of this unit focuses on the idea that resistors were developed to provide high resistivity in a small package. Types of resistors, coding systems, and the concepts of resistor value accuracy (tolerance) should be explored in a variety of appropriate exercises.

Suggested Presentation Hints/Methodology

Use this unit as a basic guideline for presenting the curriculum; however, note the following:

1. Traditionally, the topic of wire resistance precedes a discussion on resistive devices. This sequence is still recommended.
2. In this unit the phrase *type of resistor* refers to the resistor's internal composition (carbon, wire wound, or film), and the phrase *resistor variety* alludes to the physical style (fixed, adjustable, or variable). When presenting this topic, display samples of the components that are available in the shop to help students become more familiar with their physical properties.
3. The students should be asked to memorize the complete color code system prior to the class presentation on color codes. Select different students to recite the colors and the number values.
4. The concept of resistor tolerance and the method of determining specific tolerance ranges are difficult for beginning students to comprehend. Walking the student through some simple problems will improve his or her understanding and confidence. A review of basic mathematical skills and knowledge, such as percentage determination and decimals, can be of great assistance to slower students and is recommended.

Supplemental Activities and Demonstrations

The following supplemental activities and demonstrations are suggested for use in presenting the curriculum:

1. Make a demonstration display that includes a sample of resistors of various types, color code markings, and physical styles. Cement the parts on a board and label them.
2. Make informative visual aids by using an old cardboard container that has a cylindrical shape.

Insert a long welding rod through the container and plug the ends. This assembly will simulate the body of the resistor with pigtails. Paint the body with one solid color and add various color bands with color tape.

3. Using a flat piece of cardboard in the shape of a carbon composition resistor, construct a mock resistor with four see-through pockets on one end. Use paper of different colors in each pocket to simulate a coded resistor. Hold the display up so that the class can view and discuss it.

Instructional Unit Contents

1. Unit Outline (overhead)
2. Pretest and Post-test (keyed)
3. Technical Glossary
4. Work Sheet (vocabulary)—Know Your Definitions
5. Work Sheet—Resistor Color Coding and Decoding
6. Activity
7. Informational Handout (The Resistor Color Code)
8. Informational Handout (Resistors—What They Are and How They Function)
9. Answer Key for Unit 13

Unit 13

Resistance and Resistors

(Lecture Outline)

A. Wire Resistance

B. Resistors
   1. Types of resistors
   2. Fixed and variable variety

C. Resistor Color Code
   1. Ohmic value
   2. Tolerance

Test number ________

Examination for Unit 13

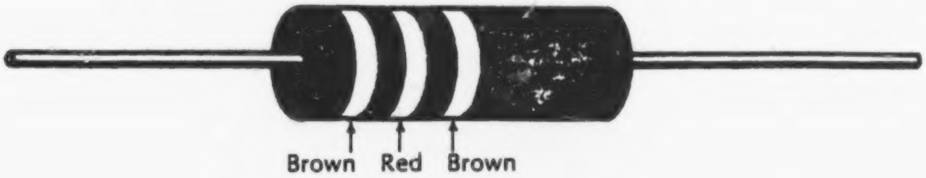
Resistance and Resistors

Write your answers to the questions on the answer sheet. Fill in the box that corresponds to the correct answer to the question. Each question has only one correct answer.

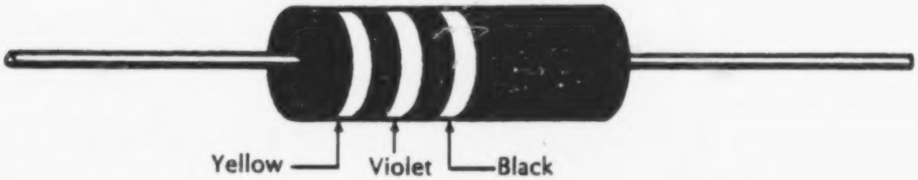
1. A conductor is a material that provides a high-resistance path for current flow. (T-F)
2. The resistance of a wire increases with any increase in the wire's length. (T-F)
3. Equal-size pieces of gold wire and aluminum wire would have the same resistance. (T-F)
4. The resistance of a wire decreases with any decrease in the diameter or cross-sectional area of the wire. (T-F)
5. Changing the temperature of a conductor will not affect its overall resistance. (T-F)
6. Fixed resistors have the advantage that their resistance values can be easily adjusted by either rotating a shaft or moving a slider. (T-F)
7. Potentiometers and rheostats are variable-type resistors. (T-F)
8. Wire-wound resistors generally offer better accuracy and higher power ratings than carbon composition resistors. (T-F)
9. The resistance value of a carbon composition resistor is clearly labeled on the body of the device; for example, 1,000Ω ±10 percent. (T-F)
10. If a 100-ohm resistor has a tolerance of 10 percent, its actual value can be between 90 and 110 ohms. (T-F)

For questions 11 through 14, record the ohmic values of the color coded resistors.

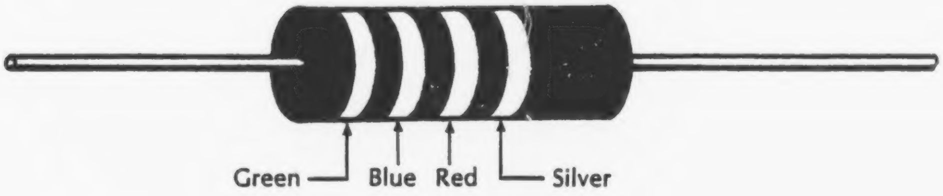
11.



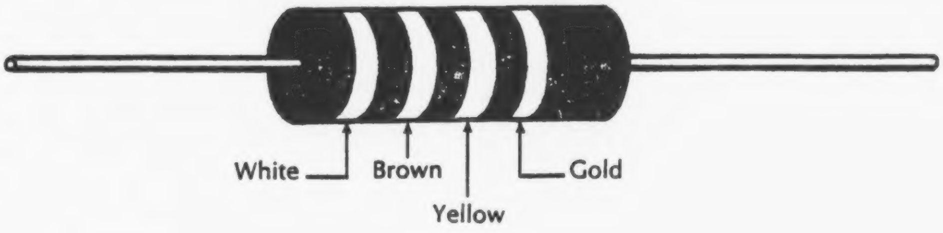
12.



13.


Green
Blue
Red
Silver

14.


White
Brown
Yellow
Gold

For questions 15 through 18, color code the following resistor value:

1,800,000Ω ±5 percent

15. First color band ____________________

16. Second color band ____________________

17. Third color band ____________________

18. Fourth color band ____________________

For questions 19 and 20, compute the tolerance range for a 6,800Ω ±10 percent resistor.

19. Lower value ______________

20. Upper value ______________

Technical Glossary

Adjustable resistor—A wire-wound-type resistor with a movable contact. The resistance between the movable terminal and either end of the resistor can be adjusted by sliding the contact across the resistance element. These resistors are made in such a way that frequent adjustment is impractical.

Carbon composition resistor—The most common type of resistor used in electronic devices. It contains carbon as its resistance material, and a series of color bands are used to code its ohmic value.

Color codes—A system of three or four color bands painted around the resistor to indicate its ohm value. Each color in the code translates to a number equivalent.

Conductance—The measure of the ability of a wire or circuit to conduct or allow an electric current flow. Conductance is measured in the basic unit siemens (formerly mho). The letter symbol is S.

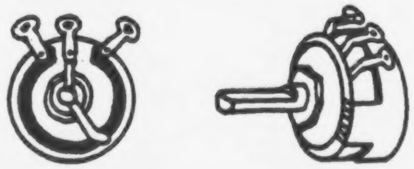
Film resistor—A type of resistor which offers better accuracy and stability than carbon composition resistors. This resistor uses a thin layer of carbon, metal, or metallic oxide as its resistance material.

Fixed-value resistor—A resistor which has only one resistance value. Fixed resistors can be either carbon composition, wire-wound, or film type.

Ohmic value—The ohm rating or value of a resistor.

Potentiometer—A type of variable resistor consisting of resistance material and a movable arm. A terminal is attached to each end of the resistance material and to the movable arm. The output resistance can be set by adjusting the movable arm. When all three of the terminals are connected into a circuit, the device is called a potentiometer. If only the center terminal (arm) and one of the end terminals are used, the device is called a rheostat.

POT



Resistor—An electrical component used to oppose the flow of electrons through a circuit. Resistors are designed to offer a specific resistance or opposition to current, and this resistance is measured in ohms. The symbol for a resistor is -/\/\/\- , and the letter symbol is R.

Tolerance—The amount by which the actual value of a component may vary from its marked value and still be considered good. Tolerances are usually expressed as a percentage. For example, the value of a 1,000Ω resistor with a 10 percent tolerance can vary between 900Ω and 1,100Ω.

Variable resistor—A type of resistor built to be easily adjusted to different values. These resistors provide a continuously variable ohmic value over the range of the device. For example, a 1,000Ω variable resistor can be adjusted to any value between 0 and 1,000 ohms. Potentiometers and rheostats are variable resistors.

Wattage rating—A measurement of the amount of power that a resistor can handle in relation to its physical size. Excessive power will cause a resistor to overheat and burn up.

Wire gauge—A numbering system used to measure the diameter of wire. The American Standard Wire Gauge system uses 44 gauge numbers ranging from 0000 to 40. The larger the gauge number, the smaller the wire diameter.

Wire-wound resistor—A type of resistor which offers a combination of high accuracy and high power ratings. These resistors are made by winding a special resistance wire on an insulated core.

Score ________

Grade ________

Name ________

Date ________

Period ________

Work Sheet

Know Your Definitions

Write a short definition in your own words for the following terms. Include a sketch when appropriate.

1. Color code
2. Potentiometer
3. Resistor
4. Wattage rating
5. Carbon composition resistor
6. Ohmic value
7. Film resistor
8. Tolerance
9. Wire gauge
10. Wire-wound resistor
11. Conductance
12. Adjustable resistor

Score ________

Grade ________

Name ________________________

Date ________________________

Period ________________________

Work Sheet

Resistor Color Coding and Decoding

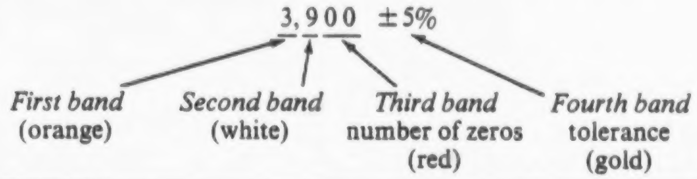
Determine the resistance value of the following color coded resistors.

Example:

	First band	*Second band*	*Third band*	*Fourth band*		
A.	yellow 4	violet 7	brown 0	silver ±10%	A.	470Ω ±10%

	First band	*Second band*	*Third band*	*Fourth band*		
1.	Brown	Red	Brown	None	1.	
2.	Yellow	Violet	Orange	Silver	2.	
3.	Orange	White	Red	Gold	3.	
4.	Blue	Gray	Black	None	4.	
5.	Green	Blue	Yellow	Gold	5.	
6.	Brown	Black	Red	Silver	6.	
7.	Gray	Red	Orange	Silver	7.	
8.	Brown	Gray	Green	None	8.	
9.	Red	Violet	Brown	Gold	9.	
10.	Brown	Green	Blue	Silver	10.	

Complete the color coding of the following resistors by using the system shown below. This technique can be used when converting a number value to a color code equivalent.


3,900 ±5%
First band (orange)
Second band (white)
Third band number of zeros (red)
Fourth band tolerance (gold)

Example:	*First band*	*Second band*	*Third band*	*Fourth band*	
120Ω ±10%	Brown	______	Brown	Silver	Red
11. 3,300Ω ±5%	Orange	Orange	______	Gold	11. ______
12. 47Ω ±20%	______	Violet	Black	None	12. ______
13. 680Ω ±10%	Blue	______	Brown	Silver	13. ______
14. 56,000Ω ±10%	______	Blue	Orange	Silver	14. ______
15. 120,000Ω ±5%	Brown	Red	______	Gold	15. ______
16. 2,500Ω ±20%	Red	(A)______	(B)______	None	16A. ______ 16B. ______
17. 1,000,000Ω ±5%	Brown	(A)______	(B)______	(C)______	17A. ______ 17B. ______ 17C. ______

Extra challenge:

18.	Blue ______	Gray ______	Gold ______	Silver ______	18. ______

Score ________

Grade ________

Name ____________________

Date ____________________

Period ____________________

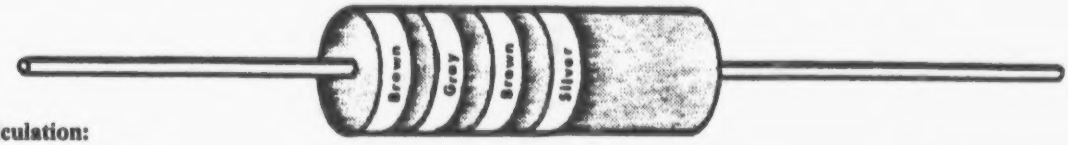
Work Sheet

Activity

In this activity you will color code resistors for assigned values and compute their tolerance ranges. Use the cutouts on the attached sheet as the color bands for the blank resistors drawn below. Use color pencils to shade in each cutout.

Example:

Color code a 180Ω ±10 percent resistor and determine its tolerance range.



Calculation:

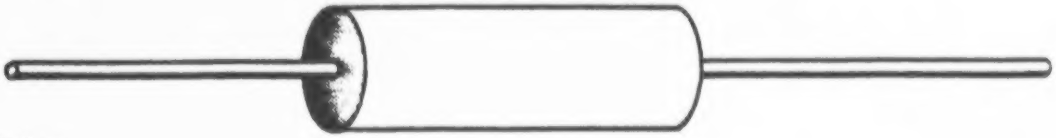
Percentage	Upper limit	Lower limit	Tolerance range
180	180	180	from 198Ω to 162Ω
× 0.10	+ 18	− 18	
000	198	162	
180			
18.00			

1. Color code a 12,000Ω ±5 percent resistor and determine its tolerance range.

Calculation:

Percentage	Upper limit	Lower limit	Tolerance range
			from to

2. Color code a 5,600Ω ±5 percent resistor and determine its tolerance range.



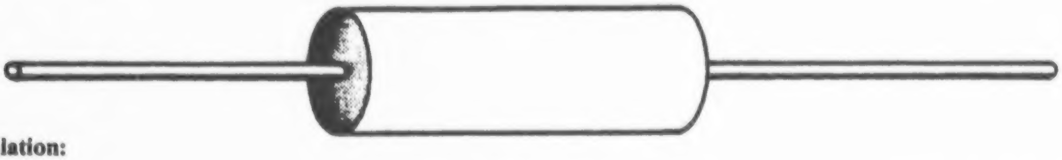
Calculation:

Percentage	Upper limit	Lower limit	Tolerance range

from to

---

3. Color code a 47Ω ±20 percent resistor and determine its tolerance range.



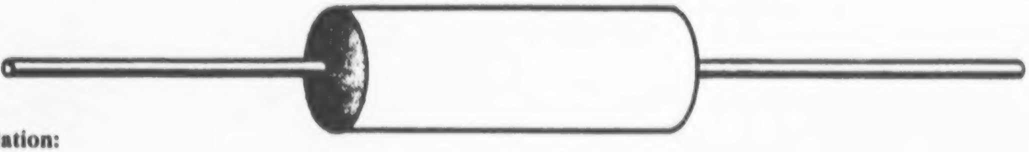
Calculation:

Percentage	Upper limit	Lower limit	Tolerance range

from to

---

4. Color code an 850,000Ω ±10 percent resistor and determine its tolerance range.



Calculation:

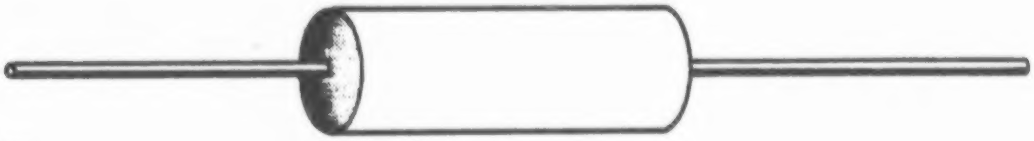
Percentage	Upper limit	Lower limit	Tolerance range

from to

Special Quest

Have your teacher assign you an individual resistance value. Color code that resistor and compute its tolerance range.

Resistance value: ____________________

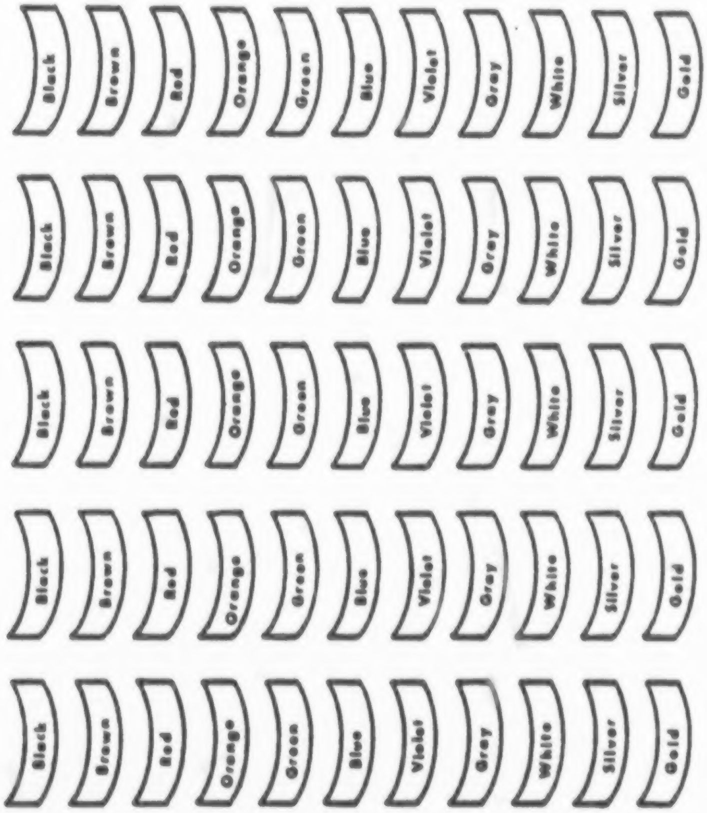


Calculation:

Percentage ____ Upper limit ____ Lower limit ____ Tolerance range ____

from ________ to ________

CUT


Black
Brown
Red
Orange
Green
Blue
Violet
Gray
White
Silver
Gold

Informational Handout

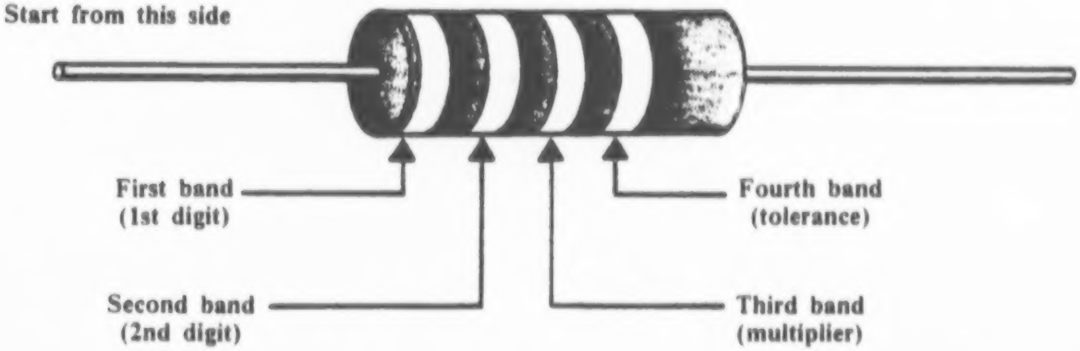
The Resistor Color Code

Carbon composition resistors use a system of three or four color bands painted on the body to indicate ohmic value. Each color translates into a number or percentage equivalent. The system works as follows:

Color code chart:

Color code	First color band— First digit	Second color band— Second digit	Third color band— Number of zeros to add	Fourth color band— Tolerance
0 Black		0	0	No color 20%
1 Brown	1	1	1	Silver 10%
2 Red	2	2	2	Gold 5%
3 Orange	3	3	3	
4 Yellow	4	4	4	
5 Green	5	5	5	
6 Blue	6	6	6	
7 Violet	7	7	7	
8 Gray	8	8		
9 White	9	9		
Gold	-	-	÷ 10	
Silver	-	-	÷ 100	

Locating the color bands:

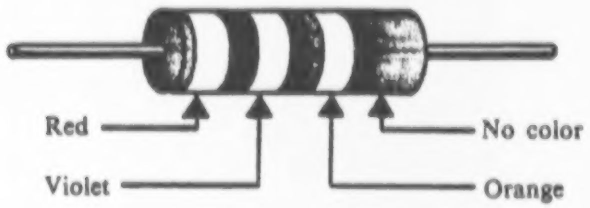

Start from this side
First band (1st digit)
Second band (2nd digit)
Third band (multiplier)
Fourth band (tolerance)

Using the color code:

Although the color code appears to be complicated, it is actually easy to use once you have mastered it. These are the points to remember:

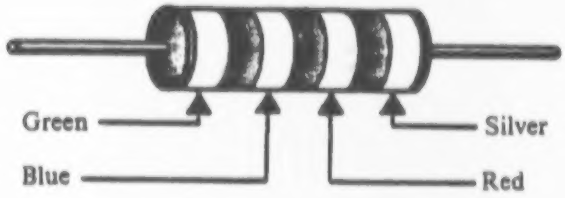
- The first color band represents the first digit.
- The second color band represents the second digit.
- The third color band basically tells how many zeros are added to the first two digits.
- The fourth color band indicates the ± tolerance.

Example:



Red = 2
Violet = 7
Orange = (3) 000
No color = ±20%

Total value = 27,000Ω ±20%



Green = 5
Blue = 6
Red = (2) 00
Silver = ±10%

Total value = 5,600Ω ±10%

Informational Handout

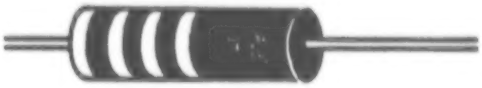
Resistors: What They Are and How They Function

A resistor, as the name implies, offers resistance to the flow of electric current. Most electronic circuits require a number of resistors for such tasks as reducing voltages and limiting current.

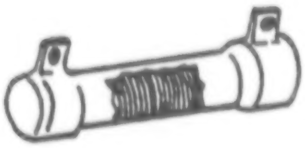
A resistor may be of a fixed, adjustable, or variable value. The terms *potentiometer, rheostat,* and *volume control* are often used interchangeably to describe variable-style resistors, but they are not the same thing. A potentiometer and rheostat are devices that can be varied mechanically, such as by turning a shaft or moving a slider. A potentiometer is a three-terminal variable resistor with connections at both ends and to a center moving contact. The rheostat is a two-terminal variable resistor with a connection to a moving slider and only one end. Study the diagrams on page 183, which show the internal connections of both devices. A volume control is a potentiometer used in a specific application.

Polarity is not a consideration when connecting fixed value resistors in a circuit. Thus, a resistor may be oriented in either direction in the circuit. Many wire-wound resistors can produce enough heat in operation to cause serious burns. Therefore, be cautious when handling resistors in a circuit that has just been turned off.

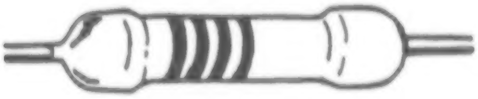
Resistors are made in three basic types: carbon composition, wire-wound, and film. These same materials can be used to construct either fixed-value or variable-style resistors in a large number of ohmic values.



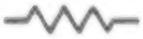
Carbon Composition Resistor

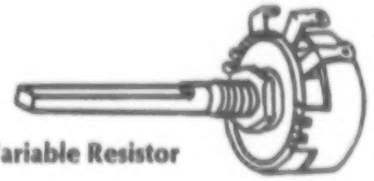


Wire-Wound Resistor

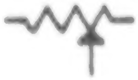


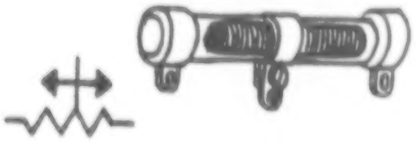
Film Resistor

Fixed-Value Resistor 

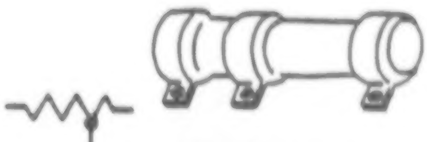


Variable Resistor

(Potentiometer) 



Adjustable Resistor

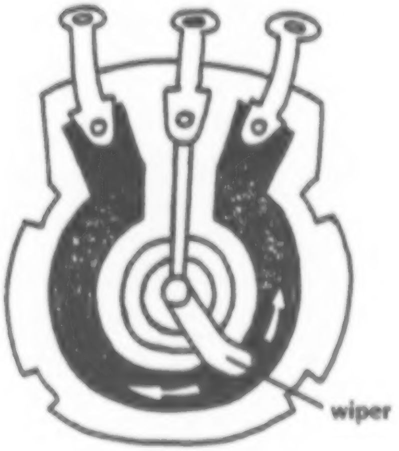


Tapped Resistor

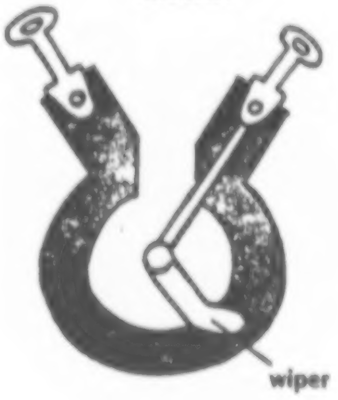
All resistors have three important specifications:

1. *Value.* Given in ohms, kilohms (kΩ—thousands of ohms), and megohms (MΩ—millions of ohms). The word *ohm* is often represented by the Greek letter *omega* (Ω).
2. *Wattage.* Specified in watts or fractions of a watt. This is the amount of electrical power the resistor can safely dissipate as heat.
3. *Tolerance.* Given as a percentage figure; indicates the possible variation in a resistor's actual value from its normal rated value. For example, a 1,000-ohm, 10 percent resistor may have an actual value somewhere between 900 and 1,100 ohms.

Potentiometer



Rheostat



Score ________

Grade ________

Name ____________________

Date ____________________

Period ____________________

Answer Key
for Unit 13

	T	F		
	1	2	3	4
1.		■		
2.	■			
3.		■		
4.		■		
5.		■		
6.		■		
7.	■			
8.	■			
9.		■		
10.	■			
11.	120Ω ±20%			
12.	47Ω ±20%			
13.	5,600Ω ±10%			
14.	91,000Ω ±5%			
15.	Brown			
16.	Gray			
17.	Green			
18.	Gold			
19.	6,120Ω			
20.	7,480Ω			
21.				
22.				
23.				
24.				
25.				

Know Your Definitions

1. (Answers will vary.)
2. (Answers will vary.)
3. (Answers will vary.)
4. (Answers will vary.)
5. (Answers will vary.)
6. (Answers will vary.)
7. (Answers will vary.)
8. (Answers will vary.)
9. (Answers will vary.)
10. (Answers will vary.)
11. (Answers will vary.)
12. (Answers will vary.)

Resistor Color Coding and Decoding

1. 120Ω ±20%
2. 47,000Ω ±10%
3. 3,900Ω ±5%
4. 68Ω ±20%
5. 560,000Ω ±5%
6. 1,000Ω ±10%
7. 82,000Ω ±10%
8. 1,800,000Ω ±20%
9. 270Ω ±5%
10. 15,000,000Ω ±10%
11. Red
12. Yellow
13. Gray
14. Green
15. Yellow

16A. Green

16B. Red

17A. Black

17B. Green

17C. Gold

18. 6.8Ω ±10%

Activity

1. Brown, red, orange, gold
   tolerance range from 12,600Ω to 11,400Ω
2. Green, blue, red, gold
   tolerance range from 5,880Ω to 5,320Ω
3. Yellow, violet, black
   tolerance range from 56.4Ω to 37.6Ω
4. Gray, green, yellow, silver
   tolerance range from 935,000Ω to 765,000Ω
5. (Answers will vary.)

Unit 14

Electric Lamps and Heating Devices

Title of Unit: Electric Lamps and Heating Devices

Time Allocated: One week

Unit Goal

To promote an interest in and a technical understanding of electrical devices used in basic illumination and heating and to emphasize the significance of these devices to daily life-styles

Unit Objectives

The student will be able to do the following:

1. Identify the operational differences between the incandescent and fluorescent lamps used in homes.
2. Describe the advantages and disadvantages of each type of lamp discussed in this unit and explain the relationship between a lamp's size and its power rating.
3. Explain the concept of heat generation in terms of current flow and resistance and give several applications of this concept.

Evaluation

The student will demonstrate his or her competence in the unit objectives on the basis of performance criteria established by the individual instructors. The criteria may include a combination of written, oral, and laboratory testing procedures.

Instructor's References

Buban, Peter, and Marshall L. Schmitt. *Understanding Electricity and Electronics* (Fourth edition). New York: McGraw-Hill Book Co., 1981.

Steinberg, W. F., and W. B. Ford. *Electricity and Electronics* (Fourth edition). Chicago: American Technical Society, 1972.

Overview

This unit deals with the historical development of illuminating devices.

The instructor should concentrate on the development of the incandescent lamp and include a detailed analysis of its internal electrical operation.

The topic of glow lamps is divided into two subcategories, but generally emphasis is placed on fluorescent lamps because of their widespread consumer application.

The unit should be continued with a brief narrative on the generation of heat from electrical energy.

Suggested Presentation Hints/Methodology

Use this unit as a basic guideline for presenting the curriculum; however, note the following:

1. Suggest a field trip to a museum to help in explaining the historical nature of electric lamps and heating devices. Many museums have displays which show the development of lighting, and the impact of such displays is generally far greater than a lecture presentation.
2. In discussing power ratings, point out that a rating indicates the ability of the device to convert electrical energy to either light or heat energy. Have an assortment of devices handy to illustrate the relationship of physical size to power rating.
3. Compare the economics of using an incandescent lamp instead of a fluorescent lamp. Discuss the economy of leaving a fluorescent lamp burning continually. Additional resource information is generally available from Sylvania, General Electric, and Westinghouse.
4. If time permits, point out that mercury-vapor lamps emit ultraviolet rays and that these rays are of the same type as those in special application lamps, such as sunlamps, blacklight lamps, and germicidal lamps.

Supplemental Activities and Demonstrations

The following supplemental activities and demonstrations are suggested for use in presenting the curriculum:

1. Collect and display a variety of incandescent lamps. Such a collection can either highlight the advances in the use of electricity for illumination or depict the size and wattage relationships of lamps for a comparative analysis.

2. Construct a fluorescent lamp circuit and use it to demonstrate more vividly the fundamental principles of operation. Discuss the advantages and disadvantages of fluorescent lamps.
3. Purchase at the local hardware store a nichrome heating unit mounted in a socket and demonstrate to the class how this device provides an intense heating source from electrical energy. Discuss its operation in conjunction with the information presented in this unit.

Instructional Unit Contents

1. Unit Outline (overhead)
2. Pretest and Post-test (keyed)
3. Technical Glossary
4. Work Sheet (vocabulary)—Scrambled Word Puzzle
5. Activity
6. Informational Handout (Historical Development of Illuminating Devices)
7. Informational Handout (Incandescent and Fluorescent Lamps and Circuits)
8. Answer Key for Unit 14

Unit 14

Electric Lamps and Heating Devices

(Lecture Outline)

A. Incandescent Lamps
  1. Heating effect
  2. Sizes, voltage, and power ratings
  3. Physical construction

B. Glow Lamps
  1. Neon type
  2. Fluorescent variety

C. Electric Heating Elements
  1. Internal construction
  2. Applications

Test number ________

Examination for Unit 14

Electric Lamps and Heating Devices

Write your answers to the questions on the answer sheet. Fill in the box that corresponds to the correct answer to the question. Each question has only one correct answer.

1. A neon lamp contains a filament. (T-F)

2. Heat is produced when current flows through a filament. (T-F)

3. Thomas Edison invented the carbon filament incandescent lamp. (T-F)

4. The visible light produced by a fluorescent lamp is actually caused by glowing phosphor atoms. (T-F)

5. A glow lamp requires a relatively low voltage (5 to 20 volts) to ionize the gases trapped within it. (T-F)

6. As the amount of current flowing through a heating element increases, the heat produced decreases. (T-F)

7. The wattage rating of a lamp indicates the amount of electrical power the lamp requires for proper operation. (T-F)

8. An incandescent lamp is more efficient to operate than a fluorescent lamp with a similar wattage rating. (T-F)

9. The filament in a standard incandescent lamp is made of:

   1. Copper
   2. Nichrome
   3. Aluminum
   4. Tungsten

10. The light output of a lamp, either incandescent or fluorescent, is given in:

    1. Lumens
    2. Watts
    3. Foot-candles
    4. Candlepower

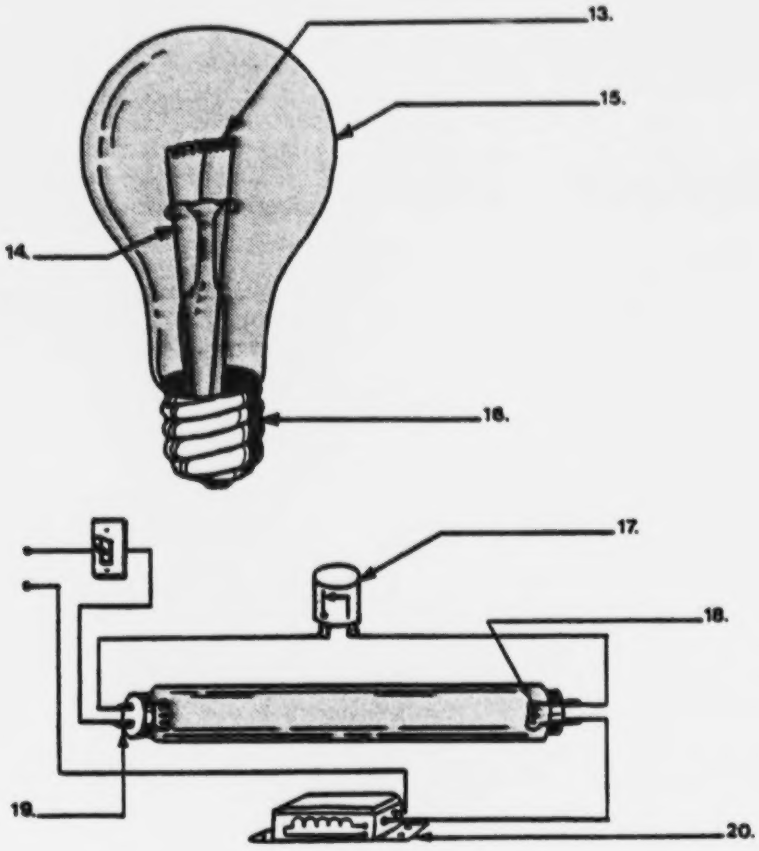
11. For proper operation, a small amount of which of the following must be contained within the fluorescent lamp tube?

    1. Oxygen
    2. Neon gas
    3. Mercury vapor
    4. Fluorine gas

12. So that the filament life of an incandescent lamp is increased, the envelope is evacuated and a small amount of which of the following is added?

    1. Argon gas
    2. Hydrogen gas
    3. Indium gas
    4. Mercury vapor

For questions 13 through 20 identify the parts of the incandescent lamp and the fluorescent lamp system shown below.


13.
15.
14.
16.
17.
18.
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20.

13.

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19.

20.

Technical Glossary

Filament—The light-producing part of an incandescent lamp, which consists of a coil of resistance wire (usually tungsten) that heats up and glows as current flows through it.

Fluorescent lamp—A common type of lamp which operates by passing an electric current through a gas. A typical fluorescent lamp consists of an evacuated glass tube with an inner coating of phosphor and a tungsten filament sealed into each end. When a high voltage is applied, mercury gas within the tube will ionize and glow. The light produced by the glowing mercury is invisible, but when it strikes the phosphor coating, the phosphor is caused to fluoresce, or glow, producing visible light. Fluorescent lamps have the advantage of high operating efficiency because they waste less energy in the form of heat. A 40W fluorescent lamp will produce approximately three times the light that a 40W incandescent lamp will provide.

Glow lamp—A lamp which has no filament. In this type of lamp, the glass envelope is filled with a special gas which glows brightly when a voltage is applied. Generally, this voltage is relatively high, from 55 to several hundred volts. This high voltage causes the gases in the lamp to ionize.

Heating effect—A phenomenon which occurs each time an electrical current flows through a wire or a resistance. The simple process of passing a current through a resistance will cause heat to be produced. The amount of heat produced depends on the amount of current and resistance. This effect is also referred to as I^2R heat.

Heating element—A device which converts electrical energy into heat. Most heating elements are simply a piece of special resistance wire which is able to heat to a high temperature without burning up.

Incandescent lamp—This most commonly used type of lamp was invented and manufactured by Thomas Edison. It uses a filament enclosed in an evacuated glass envelope to produce light. Current moving through the filament causes it to glow white hot, or incandesce, producing a brilliant light. Modern incandescent lamps use a piece of thin tungsten wire as the filament.

Ionize—The process of applying a voltage to a gas, which is contained in an envelope, causing the gas to break down or become electrically charged. Once the gas is charged, an electric current is able to flow through the gas, causing it to glow.

Neon lamp—A glow lamp which uses neon gas to produce an orange colored light. Neon lamps are commonly used as power indicators (on-off indicating lamps) and require a minimum of 55 volts to operate.

Power rating—A measurement which describes the rate at which electrical energy is converted into another form of energy, such as heat or light. Power ratings are given in watts. The symbol for watts is W.

Resistance wire—A special type of wire, made of a metal such as nichrome or tungsten, which provides a relatively high resistance to current flow. Resistance wire is commonly used to make heating elements, filaments, and wire-wound resistors.

Vacuum—The result of removing the air from a container or envelope. A *partial* vacuum exists in a fluorescent or an incandescent lamp; the residual gas may be argon, nitrogen, or other combination of inert gases, or mercury vapor (fluorescent lamps).

Score ________

Grade________

Name ________________________

Date ________________________

Period ________________________

Work Sheet

Scrambled Word Puzzle

Unscramble the letters below to identify the electronic terms.

Example:

A. AMPL	A. LAMP
1. ONNE	1. ________
2. ZONEII	2. ________
3. MUACVU	3. ________
4. MEATNILF	4. ________
5. SCCNNNEEDITA	5. ________
6. SCREENTFOUL	6. ________
7. WLGO PLMA	7. ________
8. TEAGHNI FFCTEE	8. ________
9. WREOP NTGRAI	9. ________
10. TSRANECSEI IEWR	10. ________

Use a standard dictionary and define the following terms:

11. Lumen

12. Fluorescence

Score ________ Name ______________________

Grade ________ Date ______________________

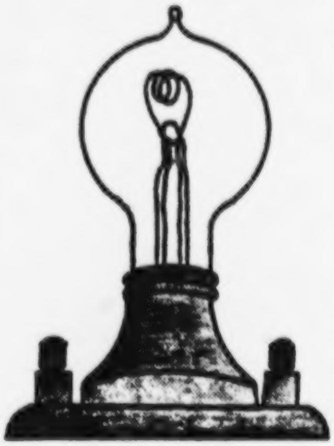
Period ______________________

Work Sheet

Activity

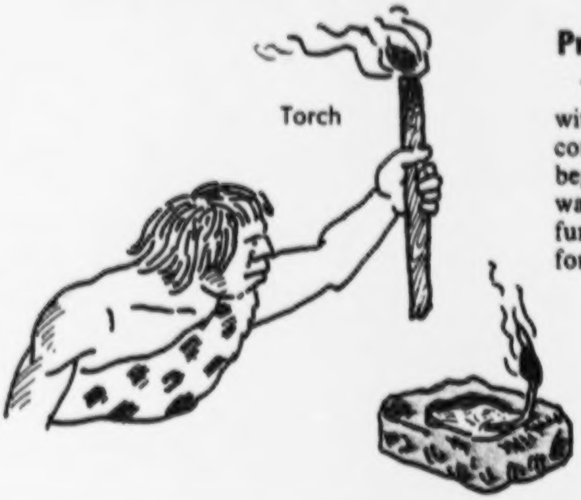
Using the appropriate resource materials (encyclopedia, books, and so forth), write a brief biographical sketch of the life and major accomplishments of Thomas A. Edison.

Thomas
Alva
Edison
(1847–1931)



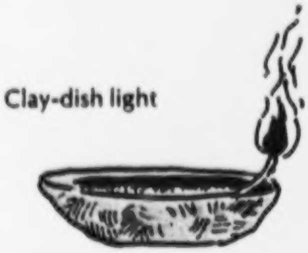
Informational Handout

Historical Development of Illuminating Devices



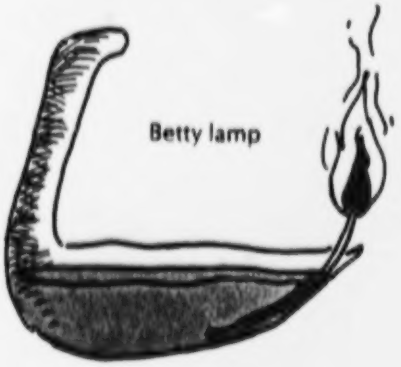
Primitive Society

The historical record of illuminating devices begins with the early cave dwellers who found the means to control fire and illuminate their caves. Soon, they began to record events by painting pictures on the walls while holding a torch. Later they created a more functional device: a hollowed-out stone with a fiber for a wick to burn fat, which was placed in the hollow.



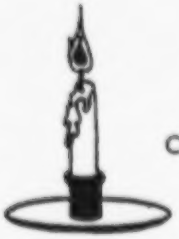
Several Hundred Years Before the Birth of Christ

The Egyptians invented a simple clay-dish light which used oil or grease for fuel with a wick of cotton. This device was easier to handle and a lot more reliable than previous lighting implements.



Early 1600s

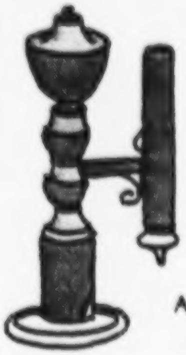
The Betty lamp had a wick inserted into a container or vat of animal fat. This design may seem crude now, but then it was thought of as being an extremely portable device which offered a long burning time. Years later this lamp was modified slightly to use either fish oil or whale oil.



Candle

Late 1600s

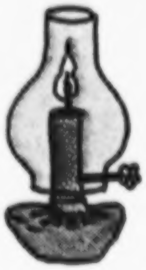
The candle is truly an ancient lighting device. It was used as a primary source of light in colonial America and is still used in a limited fashion today. Candles were made in colonial times by coating a wick with wax and pitch.



Argand lamp

Late 1700s

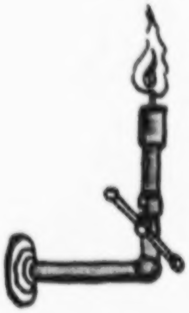
The Argand lamp contained a hollow-type wick and a glass chimney which provided a double current of air for cleaner combustion and a brighter flame. This lamp marked an important improvement or change in illumination devices.



Kerosene lamp

Mid 1800s

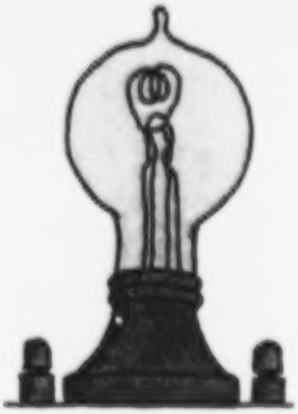
The kerosene lamp came into existence after the discovery of petroleum in 1859. The use of kerosene fuel in lamps resulted in great improvement in light quality. The addition of a mounted reflector provided maximum light in a given area.



Gas lamp

Late 1800s

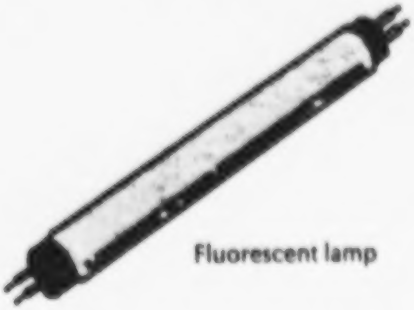
The gas lamp produces light from a small gas flame. The gas flows from the lamp through a small hole and burns after mixing with air. When these lamps were common, fuels included butane, coal gas, natural gas, and acetylene. A dangerous situation was created when the flame was blown out and the room filled with gas.



Incandescent lamp

1879

Thomas Edison perfected the first practical incandescent lamp. A carbon filament was used because of its ability to glow white hot, or incandesce, under an applied voltage. The light that was given off from the lamp was created without a flame and with a minimum of heat to the surrounding area.



Fluorescent lamp

1938

A fluorescent lamp operates by passing an electric current through a gas. This lamp consists of an evacuated glass tube with an inner coating of phosphor and a tungsten filament sealed into each end. When a high voltage is applied, mercury gas within the tube ionizes and glows. The light produced by the glowing mercury is invisible but when the light strikes the phosphor coating, the phosphor is caused to fluoresce, or glow, producing visible light. Fluorescent lamps have the advantage of high operating efficiency because they waste less energy in the form of heat.

A Thought

Through the centuries people have made many different kinds of illuminating devices. But all of them have been one of three basic types:

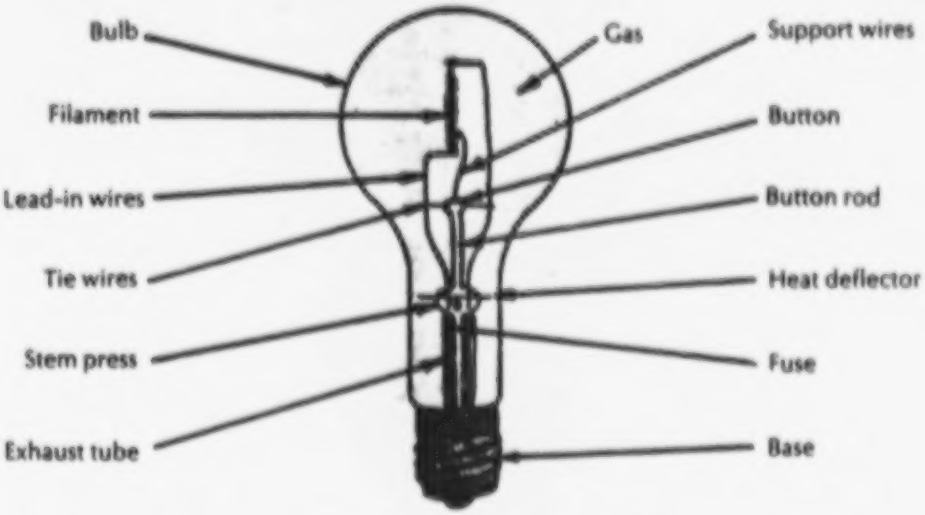
1. Fat or oil
2. Gas
3. Electric

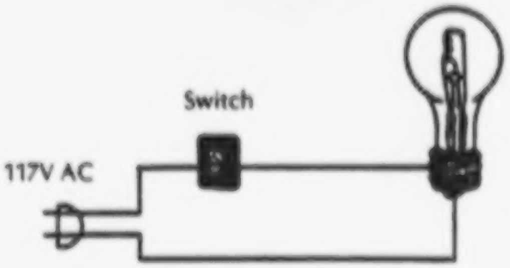
Today, electric lamps are used almost entirely for our light.

Informational Handout

Incandescent and Fluorescent Lamps and Circuits

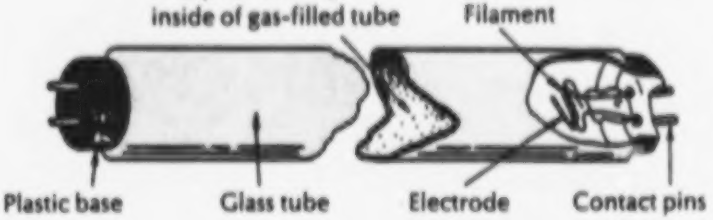
Typical Incandescent Light Bulb and Circuit

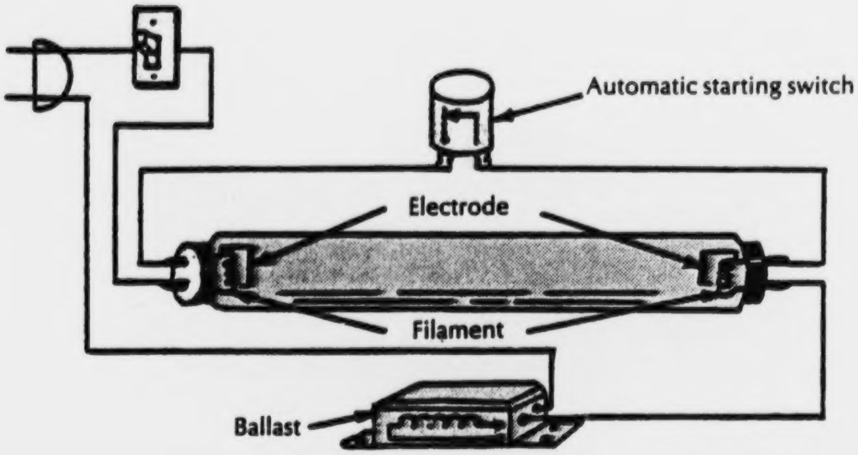

Bulb
Filament
Lead-in wires
Tie wires
Stem press
Exhaust tube
Gas
Support wires
Button
Button rod
Heat deflector
Fuse
Base


Switch
117V AC

The incandescent lamp provides a brilliant white light, which is produced by the flow of electrons through the filament. As electrons are forced through the tightly coiled tungsten filament, it heats up, glows, and gives off light.

Typical Fluorescent Light and Circuit


Phosphor coating
inside of gas-filled tube
Filament
Plastic base
Glass tube
Electrode
Contact pins



The operation of a fluorescent lamp is rather complex when compared to that of an incandescent lamp, but there are some similarities. The tube has an innner coating of phosphor atoms and is filled with a gas mixture of argon and mercury vapor. At the extreme ends of the tube is located a heating filament-electrode unit, which is connected to a set of external contact pins. In addition to the tube, a fluorescent system requires a (1) ballast coil which provides a high voltage pulse for starting the tube and also operates as a current-limiting device; and (2) starter switch which is used to time a heating cycle in which the mercury within the tube is warmed and vaporized.

After the circuit is energized, the following events occur during the starting sequence:

1. The filament units are energized and warm the mercury within the tube, forming a vapor.
2. At a preset time the starter switch opens, turning off the filaments and causing the ballast to produce a high-voltage pulse.
3. The high-voltage pulse is applied to the electrodes of the tube and causes the mercury vapor to ionize and produce invisible ultraviolet light.
4. Once the mercury is ionized, the voltage applied to the electrodes drops to about 120V. The ballast controls the circuit current so that an excessive current does not destroy the lamp.
5. So far the tube has only produced invisible light. But as this light energy strikes the phosphor atoms coated on the inside of the tube, it causes them to glow, or fluoresce, thereby producing visible light.

Answer Key
for Unit 14

	T	F		
	1	2	3	4
1.		■		
2.	■			
3.	■			
4.	■			
5.		■		
6.		■		
7.	■			
8.		■		
9.				■
10.	■			
11.			■	
12.	■			
13.	Filament			
14.	Lead-in wires			
15.	Bulb			
16.	Base			
17.	Starter			
18.	Filament			
19.	Contact pins			
20.	Ballast			
21.				
22.				
23.				
24.				
25.				

Scrambled Word Puzzle

1. Neon
2. Ionize
3. Vacuum
4. Filament
5. Encandescent
6. Fluorescent
7. Glow lamp
8. Heating effect
9. Power rating
10. Resistance wire
11. (Answers will vary.)
12. (Answers will vary.)

Activity

(Answers will vary.)

Unit 15

Electromagnetism

Title of Unit: Electromagnetism

Time Allocated: Two weeks

Unit Goals

To help the student comprehend the technical effects, application, and influence that electromagnetism has on our lives and to discover the relationship between electricity and electromagnetism

Unit Objectives

The student will be able to do the following:

1. Write or recite an explanation of the cause and effect relationship of the phenomenon referred to as electromagnetism.
2. Construct, operate, and explain the fundamental principles of an electromagnet and identify the specific factors which affect its strength.
3. List and explain the operation of common devices that use the principle of electromagnetism.

Evaluation

The student will demonstrate his or her competence in the unit objectives on the basis of performance criteria established by the individual instructors. The criteria may include a combination of written, oral, and laboratory testing procedures.

Instructor's References

Gerrish, Howard H. *Exploring Electricity and Electronics: Basic Fundamentals* (Revised edition). South Holland, Ill.: Goodheart-Willcox Co., 1978.

Loper, Orla E. *Introduction to Electricity and Electronics.* Albany, N.Y.: Delmar Publishers, 1973, Chapter 6.

Overview

In Unit 6, students were given the information they need to understand the properties of magnets and magnetism. This unit is intended to supplement that information with a more in-depth study of electromagnetism.

Hans Christian Oersted's discovery that an electric current deflects a suspended magnet (1820) is ideally suited as a point of origin for this presentation because it provides a smooth transition into the study of the characteristics of the electromagnetic field.

Next, the electromagnet should be analyzed as a component, with emphasis on methods for increasing the strength of an electromagnet's field.

Unit 15 should conclude with a discussion of the applications of electromagnets.

Suggested Presentation Hints/Methodology

Use this unit as a basic guideline for presenting the curriculum; however, note the following:

1. Try to create with the students an atmosphere of importance about the concept of electromagnetism so that they realize that this topic is one of the most important in the study of the modern electrical era. Stress that Oersted's discovery has made possible countless devices, ranging from electromagnets to motors.
2. Use a "Spell Down" activity: Organize the class into two teams. The captain of Team 1 will call out a term from the Technical Glossary of this unit; Student 1, Team 2 will spell the word, and Student 1, Team 1 will define it. Alternate this procedure and judge students' performances.
3. Use the following activity before the lecture presentation to generate some enthusiasm: Obtain a small, working, black and white TV and tune it for a local channel. Bring a strong electromagnet close to the front of the cathode ray tube (CRT) and let the class watch the picture distort. Discuss the implication.
4. Remind the students that safety is a prime consideration, especially in this unit.

Supplemental Activities and Demonstrations

The following supplemental activities and demonstrations are suggested for use in presenting the curriculum:

1. Make the students more aware of the many uses for electromagnets by describing and showing them the following devices: speakers, recorder heads, headphones, bells, buzzers, relays, motors, meters, and so on. Try to simplify and use prac-

tical examples in the explanations and demonstrations.

2. Take some extra time to explore the glossary found in this unit. It is essential to the understanding of this unit of instruction.
3. Demonstrate the action of magnetic separation by mixing iron filings and sand. Use a strong electromagnet to separate the iron filings from the sand. Discuss the students' observations.

Instructional Unit Contents

1. Unit Outline (overhead)
2. Pretest and Post-test (keyed)
3. Technical Glossary
4. Work Sheets (vocabulary)—Crossword Puzzle
5. Activity
6. Informational Handout (Electromagnetic Fields)
7. Answer Key for Unit 15

Unit 15

Electromagnetism

(Lecture Outline)

A. The Electromagnetic Effect
   1. Oersted's discovery
   2. Characteristics of the electromagnetic field
      a. Lines of force around a conductor
      b. Direction of current flow and its effect on a magnetic field
      c. Left-hand rule for wire

B. The Electromagnet
   1. Construction
   2. Left-hand rule for coils
   3. Factors affecting the strength of an electromagnet

C. Use of Electromagnets
   1. Lifting magnets
   2. Relays
   3. Solenoid
   4. Buzzers and bells

7

Test number ________

Examination for Unit 15

Electromagnetism

Write your answers to the questions on the answer sheet. Fill in the box that corresponds to the correct answer to the question. Each question has only one correct answer.

1. Ferromagnetic materials are those materials which are attracted by a magnet. (T-F)
2. Flux lines are also known as lines of force. (T-F)
3. Because flux lines do not have north and south poles, a compass cannot be used to determine that they do exist around a current-carrying conductor. (T-F)
4. The iron core of the electromagnet does not affect the strength of the magnet. (T-F)
5. Like poles repel and unlike poles attract each other. (T-F)
6. A magnetic field is made up of visible flux lines. (T-F)
7. A solenoid is an electromagnet with a movable iron core. (T-F)
8. Permeability is the measure of how long a magnet will remain magnetized. (T-F)
9. An electromagnet is a type of permanent magnet. (T-F)
10. A relay is basically an electromagnetic switch. (T-F)
11. Electromagnetism is an invisible force which attracts any metal. (T-F)
12. A temporary magnet has high retentivity or residual magnetism. (T-F)
13. Magentic lines of force that exist around a conductor are caused by current flow in the conductor. (T-F)
14. Electromagnetism cannot be produced by using alternating current. (T-F)
15. Oersted discovered that an electric current flowing in a conductor will produce magnetism. (T-F)
16. Flux lines exist around a conductor at all times. (T-F)
17. The armature of a relay must be made of a ferromagnetic material. (T-F)
18. Increasing the current flow in a solenoid will increase the strength of the electromagnet. (T-F)
19. In accordance with the left-hand rule for current-carrying coils, the thumb should point in the direction of current flow. (T-F)

20. Flux lines around a current-carrying conductor:

    1. Have no specific shape.
    2. Will appear only at certain places.
    3. Form a circular pattern around the conductor.
    4. Have north and south poles.

21. When two conductors carry opposite currents:

    1. Opposite electromagnetic fields are produced.
    2. Similar electromagnetic fields are produced.
    3. No magnetic field is produced.
    4. The two fields repel each other.

22. The left-hand rule states that the thumb points to the north pole when one works with a:

    1. Coil
    2. Straight wire
    3. Solenoid
    4. Both 1 and 3

23. What causes electromagnetism?

    1. Free electrons in the conductor
    2. Electrons flowing in the conductor
    3. A conductor
    4. An electric charge

24. A material that has high retentivity can be used for:

    1. Electromagnets
    2. Permanent magnets
    3. Temporary magnets
    4. Paramagnets

25. When a solenoid is energized with direct current, the plunger:

    1. Moves to the center of the coil and stops
    2. Moves away from the coil
    3. Moves into and drops out of the coil
    4. Will not move at all

Technical Glossary

Attraction—Attraction is the process of drawing or pulling toward an object. For example, a magnet will attract a piece of soft iron.

Bell—A buzzer with a hammer added to the moving end of the armature. The hammer is designed to strike a bell or gong each time the armature moves toward the electromagnet. The electric bell is one of the oldest household appliances.

Buzzer—An electromagnetic device which includes a flexible armature and a switching mechanism. The armature is first attracted to the energized electromagnet. At a certain point, the moving armature causes a switch contact to open, turning off the magnetic field and allowing the armature to be pulled back by a spring. This reverse motion closes the switch to reenergize the electromagnet and again attract the armature. The process is repeated over and over, creating a buzzing sound.

Core—The center of a wire coil which is used as a "form" for the wrappings of wire. The core is used to provide a magnetic path for flux lines and is commonly made of soft iron or laminated sheets of iron. Many coils do not contain an iron or metal core; plastic or cardboard tubes are used. This latter type of coil is called an air core coil.

Electromagnet—A coil of insulated wire wrapped around a soft iron core which becomes magnetic when a current is forced through it. The core acts to concentrate the magnetic lines of force and becomes magnetized when current flows through the coil.

Electromagnetism—The magnetic effect that is produced when electrons flow through a wire or coil. This invisible field produces both north and south magnetic poles, similar to a permanent magnet. The strength of this field depends on the magnitude of the current flow, the number of turns of wire in the coil, and the type of core that is used. If the current flowing through the wire or coil is stopped, the magnetic effect ceases.

Ferromagnetic material—A classification for materials which are attracted by a magnet. These magnetic materials include iron, nickel, and cobalt.

Flux lines—The lines of magnetic force or "lines of force" which exist around a magnet.

Left-hand rule—A method used to determine the polarity of the electromagnetic field surrounding a single conductor or a coil. In the case of a single conductor, the left thumb points in the direction of electron flow, and the fingers curled around the wire indicate the direction of the flux lines. To use the left-hand rule for a coil, wrap the fingers of the left hand around the coil in the direction of current flow; the thumb will then be pointing toward the coil's north pole.

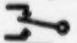
Lifting magnet—A very strong electromagnet used for moving scrap steel. The advantage of the lifting magnet is that the magnetic field can easily be switched on and off.

Magnetic field—The space around a magnet or electromagnet which is influenced or affected by its magnetic force.

Magnetic pole—The portion of a magnet where the lines of force are most concentrated. In every magnet there is one north-seeking pole (N-pole) and one south-seeking pole (S-pole).

Magnetism—The invisible force exerted by a magnet that allows it to attract ferromagnetic materials and to attract or repel other magnets or magnetic fields.

Permeability—A measure of how easily magnetic lines of force can pass through a material.

Relay—An electrical device, basically a switch, controlled or turned on and off by an electromagnet. Generally, the current flowing to the electromagnet is controlled by a separate circuit. Relays are used in several electronic devices, but they are slowly being replaced by modern solid-state switching devices. The symbol for a relay is , and the letter symbol is K.

Repulsion—The process of pushing away or forcing back an object. The north pole of a magnet will repel the north pole of a second magnet.

Residual magnetism—The magnetism remaining in a material or magnetic core after the magnetizing force is removed. The ability of a material to retain magnetism is referred to as retentivity.

Solenoid—A cylindrical electromagnet made with a movable iron core or plunger. When the electromagnet is energized, the plunger is drawn into the center of the coil. A spring pulls the plunger partially out of the coil when the circuit is deenergized. The pulling force of a solenoid can be strong enough to operate switches, locks, valves, or door chimes. Solenoids are also known as sucking coils.

Score ________

Grade ________

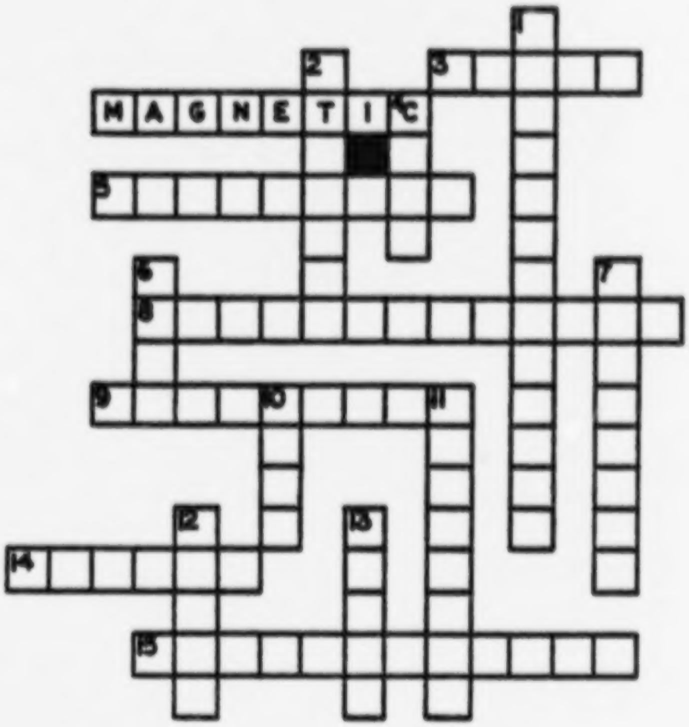
Name ________________

Date ________________

Period ________________

Work Sheet

Crossword Puzzle



Across

3. The space around a magnet which is influenced by its magnetic force
5. A type of magnet which loses its magnetism very rapidly once the magnetizing force is removed
8. A type of magnet which requires a coil of wire, soft iron core, and electric current
9. The invisible lines of force surrounding a magnet
14. An electromagnetic device which uses a flexible, vibrating armature
15. A measurement of the ease with which flux lines move through a material

Down

1. Materials which are readily attracted by a magnetic field
2. To draw or pull toward an object
4. The center of a wire coil
6. One of the oldest household electronic appliances
7. The magnetism retained by the soft iron core of an electromagnet
10. A method used to determine the polarity of an electromagnetic field; known as the ________-hand rule
11. Sucking coil
12. The opposite of attract
13. An electromagnetic switch

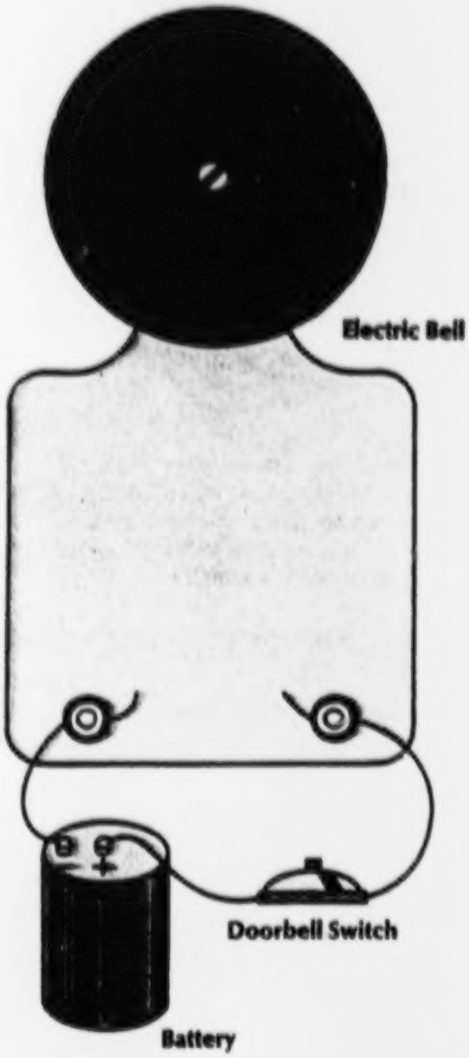
Score ________ Grade ________

Name ______________________ Date ______________________ Period ______________________

Work Sheet

Activity

Complete the drawing of the electric bell by sketching and labeling the remaining internal and external parts. Be complete and accurate. Next, describe in detail the electrical operation of the device.


Electric Bell
Doorbell Switch
Battery

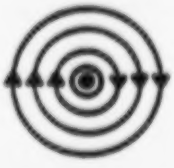
Electrical Operation

215

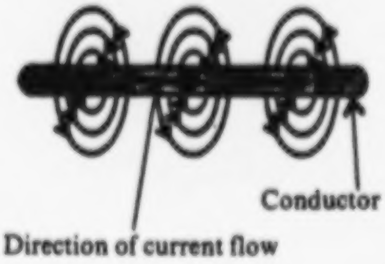
Informational Handout

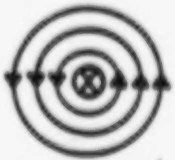
Electromagnetic Fields

Magnetic Field Around a Single Current-Carrying Conductor:



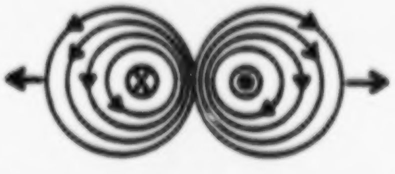
Cross-section of a conductor and magnetic field showing current flowing toward you (●)



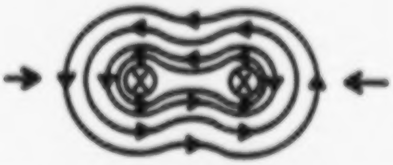


Cross-section of a conductor and magnetic field showing current flowing away from you (X)

Magnetic Interaction of Two Parallel Current-Carrying Conductors:

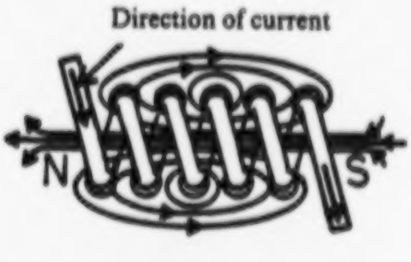


When two parallel wires carry opposite currents, opposite electromagnetic fields are developed. These fields with opposite polarities will repel each other.



When two parallel wires carry currents flowing in the same direction, similar electromagnetic fields are developed. Flux lines flowing in the same direction join, or add, causing attraction.

Magnetic Field Surrounding a Current-Carrying Coil:



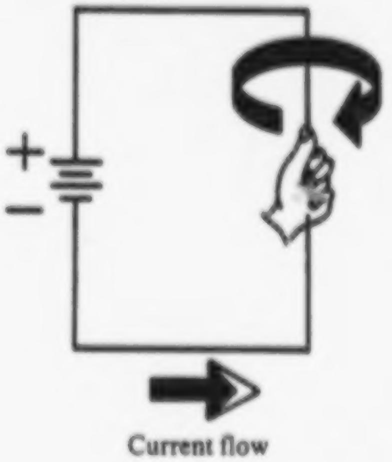
The flux lines are all flowing around a coil in the same direction, thus joining (adding) together and creating a stronger field. The strongest concentration of flux lines will be located within the center, or core, of the coil.

Increasing the Strength of an Electromagnetic Field:

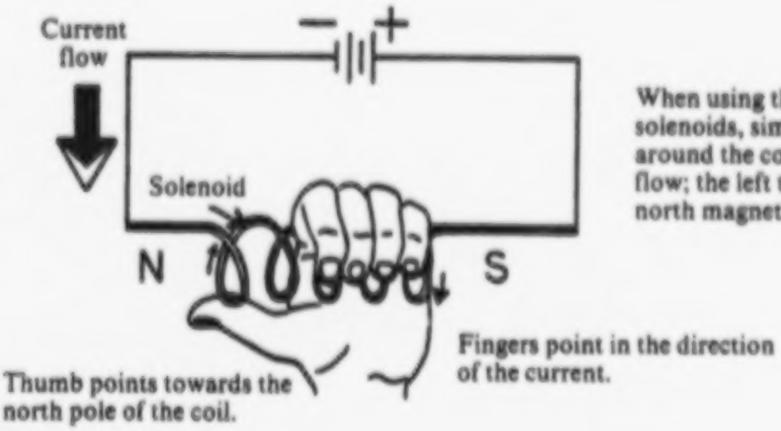
- Increasing current flow through a wire or coil will result in the strengthening of the field.
- Adding more turns of wire to a coil, or wrapping the wires closer together, will also cause an increase in magnetic strength.
- Including a soft iron core within the coil will tend to concentrate the magnetic flux lines and produce a stronger field. Thus, the type of core used in the electromagnet will affect its strength.

Left-hand Rule:

This form of the left-hand rule is used to determine the direction, or polarity, of the magnetic fields formed around a single conductor or coil.


+
−
Current flow

To use the left-hand rule for a single conductor, point your left thumb in the direction of current flow; your fingers will then wrap around the wire, pointing in the same direction as the magnetic field.


Current flow
− +
Solenoid
N
S
Thumb points towards the north pole of the coil.
Fingers point in the direction of the current.

When using the left-hand rule for coils or solenoids, simply wrap your fingers around the coil in the direction of current flow; the left thumb will point toward the north magnetic pole of the coil.

Score ________ Name ______________________

Grade ________ Date ______________________

Period ______________________

Answer Key for Unit 15

	T	F		
	1	2	3	4
1.	■			
2.	■			
3.		■		
4.		■		
5.	■			
6.		■		
7.	■			
8.		■		
9.		■		
10.	■			
11.		■		
12.		■		
13.	■			
14.		■		
15.	■			
16.		■		
17.	■			
18.	■			
19.		■		
20.			■	
21.	■			
22.				■
23.		■		
24.		■		
25.	■			

Crossword Puzzle

ACROSS

3. Field
5. Temporary
8. Electromagnet
9. Flux lines
14. Buzzer
15. Permeability

DOWN

1. Ferromagnetic
2. Attract
4. Core
6. Bell
7. Residual
10. Left
11. Solenoid
12. Repel
13. Relay

Activity

(Answers will vary.)

Unit 16

AC and DC Electricity

Title of Unit: AC and DC Electricity

Time Allocated: Two weeks

Unit Goal

To review the characteristics, terminology, and importance of both alternating current (AC) and direct current (DC) electricity

Unit Objectives

The student will be able to do the following:

1. Explain the difference between direct and alternating current.
2. Name three specific advantages that alternating current has over direct current and list at least six practical applications of alternating current.
3. Write or recite the major reasons that alternating current is the primary source of power in homes.

Evaluation

The student will demonstrate his or her competence in the unit objectives on the basis of performance criteria established by the individual instructors. The criteria may include a combination of written, oral, and laboratory testing procedures.

Instructor's References

Mileaf, Harry. Electricity One-Seven. Rochelle Park, N.J.: Hayden Book Company, Inc., 1976, Chapter 3.

Rollain, Philip J., and Thomas E. Kraus. *Exploring Electricity and Electronics with the Electrical Team.* Albany, N.Y.: Delmar Publishers, 1979.

Overview

Unit 16 is primarily a brief examination of alternating current. Students should be advised that they must be familiar with the basic characteristics of alternating current if they plan to work in the electricity/electronics field.

The unit should be formally introduced with a review of direct current. After the review is completed, present the specific characteristics, history, and general importance of alternating current.

Unit 16 should be concluded with an explanation of why alternating current is the most widely used kind of electrical current.

Suggested Presentation Hints/Methodology

Use this unit as a basic guideline for presenting the curriculum; however, note the following:

1. The unit outline calls for only a brief, yet informative, examination of alternating current; however, the instructor should make an effort to show the relationship that exists between alternating and direct currents. Unit time is better spent in analyzing the basic characteristics of alternating and direct currents rather than totally exploring the complex nature of alternating current.
2. Students need to be able to classify electrical devices by their power requirements. To help them gain this ability, indicate to them that, if an electrical device is independent, portable, or self-contained, and/or if it requires only a moderate amount of electrical power, it probably operates on direct current.
3. Typically, students have difficulty understanding that different kinds of currents sometimes coexist in the same circuit or device. Expect this problem and be prepared to elaborate on the concept. Also, impress on students that the term *signal* means alternating current but that some circuits need direct current for components to function properly.
4. A description and a demonstration of transformer action and rectification are easily handled by students as long as the theory is confined to a basic input/output analysis.

Supplemental Activities and Demonstrations

The following supplemental activities and demonstrations are suggested for use in implementing the curriculm:

1. Use an oscilloscope, if available, in an analysis of alternating current. Display waves on the screen for students to view. Students enjoy working with this kind of testing instrument, and if several students are capable, allow them to investigate the subject further.
2. Construct and discuss on the chalkboard a mock electric power transmission system. Include a power plant, a control center, transmission facili-

ties, distribution lines, and devices for increasing or decreasing the voltage.

Instructional Unit Contents

1. Unit Outline (overhead)
2. Pretest and Post-test (keyed)
3. Technical Glossary
4. Work Sheet (vocabulary)—Cryptics
5. Activity
6. Informational Handout (AC and DC Current Characteristics)
7. Answer Key for Unit 16

Unit 16

AC and DC Electricity

(Lecture Outline)

A. Characteristics of DC Current

B. What is Alternating Current?
  1. Back-and-forth motion of electrons
  2. History and importance of alternating current

C. How Do We Use Direct Current and Alternating Current Electricity?
  1. Devices that operate only on direct current
  2. Devices that operate only on alternating current
  3. Combination devices

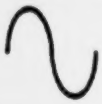
D. Why Is Alternating Current the Most Common Form of Electricity?
  1. Efficiency of generation
  2. Effective means of transmission
  3. Conversion ability
    a. Transformer action
    b. Rectification

Test number ________

Examination for Unit 16

AC and DC Electricity

Write your answers to the questions on the answer sheet. Fill in the box that corresponds to the correct answer to the question. Each question has only one correct answer.

1. The output voltage of an alternating current generator should look like a rectangular wave when displayed on an oscilloscope. (T-F)
2. Direct current electricity is supplied to our homes. (T-F)
3. Radio signals are usually alternating current-type electricity. (T-F)
4. A radio uses both alternating current and direct current electricity in its operation. (T-F)
5. The advantage of direct current electricity is that it can be easily changed to alternating current electricity by using a rectifier. (T-F)
6. Electrons always flow from the negative to the positive in a direct current circuit, but not in an alternating current circuit. (T-F)
7. Alternating current will travel a longer distance through a transmission line than a similar value of direct current. (T-F)
8. An alternator is a device used to generate either alternating current or direct current electricity. (T-F)
9. The amplitude of an alternating current wave is a measure of the wave's vertical size. (T-F)
10. The frequency of the alternating current power supplied to our homes is 117V. (T-F)
11. A complete alternating current cycle can be pictured as follows:  (T-F)
12. The process of changing direct current energy to alternating current energy is called rectification. (T-F)
13. A transformer has the ability to either step-up or step-down alternating current voltage. (T-F)
14. High frequency alternating current signals, called radio waves, can travel through the air over long distances. (T-F)
15. The telephone company sends alternating current impulses over transmission lines to produce sound. (T-F)
16. An alternating current wave changes in:
    1. Direction only
    2. Value only
    3. Both value and direction
    4. Frequency and value but not direction

17. Alternating current is used as:

1. A source of electrical power and a means of carrying information or intelligence
2. A source of power only
3. A means of carrying information only
4. An alternating current signal only

18. The number of alternating current cycles produced in one second is called:

1. An alternation
2. The sine curve
3. The frequency
4. An alternating current

19. Identify the device which has the ability to convert alternating current energy of one voltage and current value to another combination of E and I:

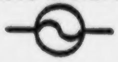
1. Rectifier
2. Alternator
3. Transformer
4. Generator

20. Which is an advantage of alternating current?

1. It can easily be changed to direct current.
2. It can travel efficiently through long-distance transmission lines.
3. It can be transformed from one voltage to another with minimal power loss.
4. All of the above.

Technical Glossary

Alternating current—An electrical current which flows first in one direction, stops, and then flows in the opposite direction. Alternating current can be thought of as a back-and-forth movement of electrons, varying in amplitude from a maximum to a minimum value. The alternating current signal is depicted as a sine wave . The abbreviation for alternating current is AC.

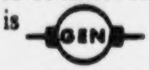
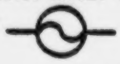
Alternator—An alternating current generator that uses a stator, rotor, slip rings, and brushes to produce electricity. The symbol for an alternator is , and the letter symbol is GEN.

Amplitude—The vertical size or height of an alternating current wave.

Cycle—One complete alternating current wave. One cycle consists of two alternations, one positive and one negative.

Direct current—An electrical current which flows in one direction through a circuit from negative to positive. The abbreviation for direct current is DC.

Frequency—The number of complete alternating current waves or cycles which occur during a particular amount of time, usually 1 second. Frequency is measured in the basic unit hertz. The symbol for frequency is f.

Generator—A machine used to produce electricity, either alternating current or direct current, by causing a series of interconnecting coils to cut or be cut by a magnetic field. The symbol for the DC generator is , and the symbol for the AC generator is . The letter symbol is GEN.

Power frequency—The frequency of alternating current electricity used for household energy or power. The power frequency used in the United States is 60 hertz.

Power loss—The loss of electrical energy due to resistance. The combination of current flow and wire resistance will produce heat, causing electrical power to be wasted or lost.

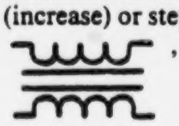
Radio-frequency wave—A high-frequency alternating current signal used to carry intelligence or messages through the air. Radio waves, for example, are used to carry radio and television signals.

Rectification—The process of changing alternating current to direct current.

Signal—A changing alternating current voltage which contains information. Certain alternating current signals, for example, can be changed into sound, light, or magnetic pulses.

Sine wave—The output wave produced by an alternating current generator. One complete sine wave can be drawn as follows:

Sound-frequency wave—A low-frequency alternating current signal which when applied to a speaker will produce sound that can be heard by the human ear.

Transformer— An electronic device that consists of two or more coils of wire and that has the ability to either step-up (increase) or step-down (decrease) an alternating current voltage. The symbol for a transformer is , and the letter symbol is T.

Transmission line—A wire or heavy cable used to conduct or guide electrical energy from one point to another. Transmission lines generally carry very high voltages, often 132,000 volts or more.

Score ____________

Grade ____________

Name ______________________________

Date ______________________________

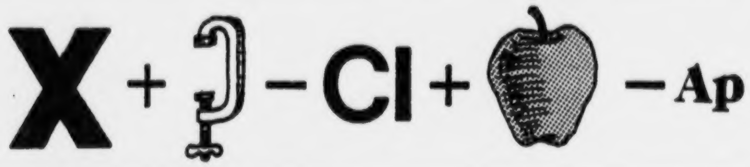
Period ______________________________

Work Sheet

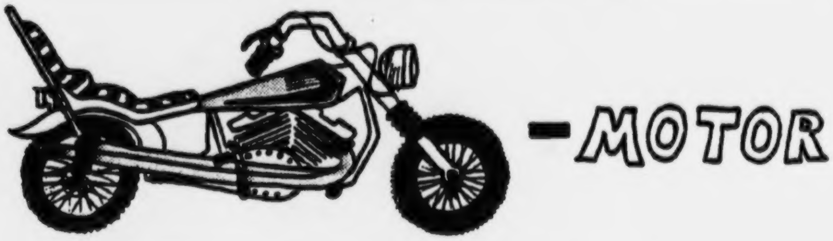
Cryptics

Decode the cryptic messages below and identify the electronic terms that sound similar to the answers.

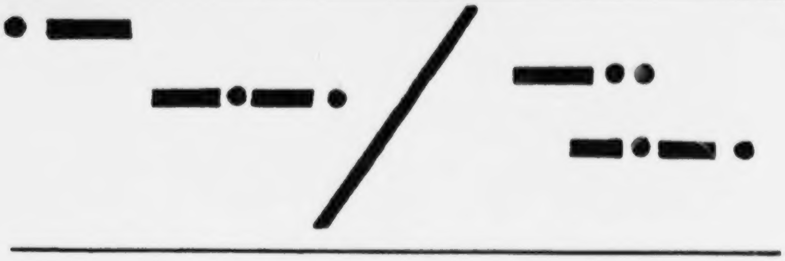
Example:



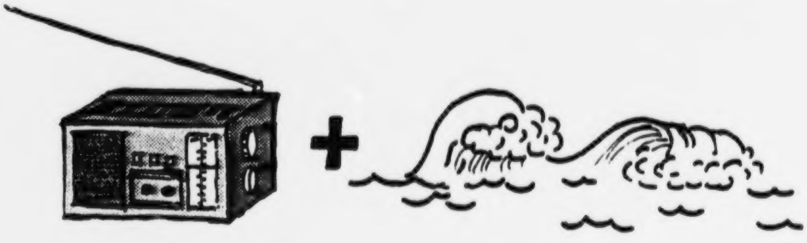
A. Example



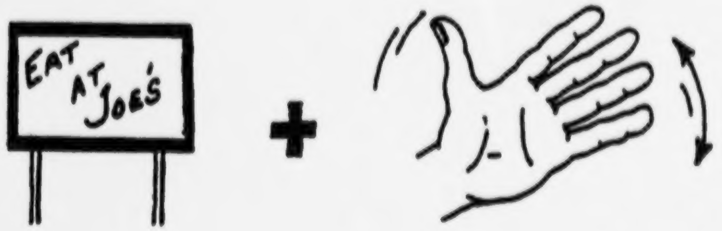
1. ____________________



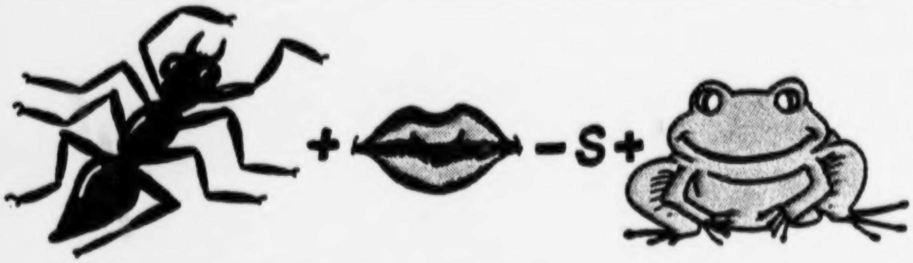
2. ____________________



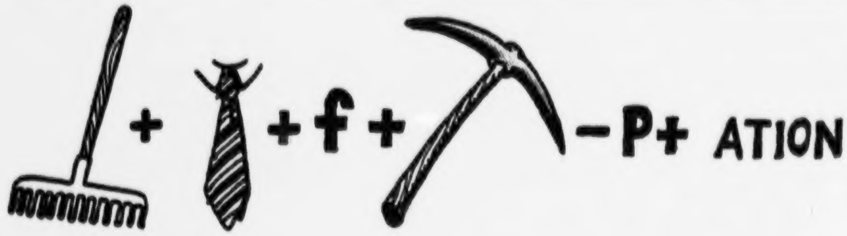
3. ____________________



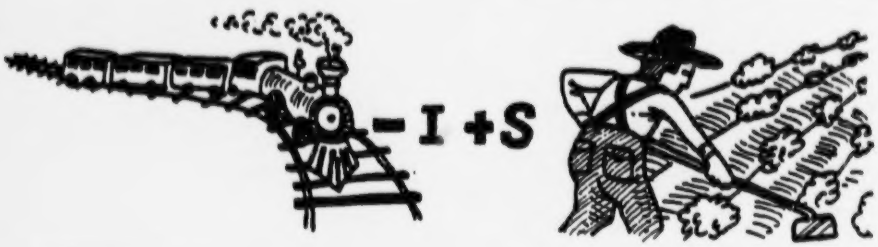
4. ______________



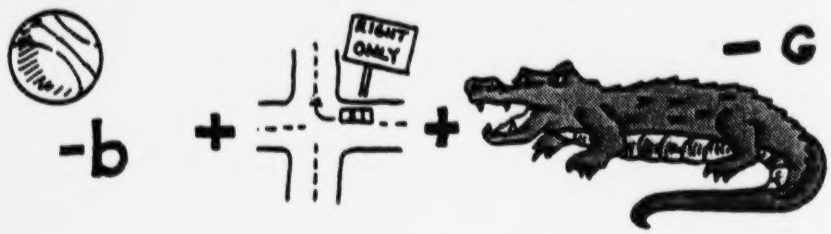
5. ______________



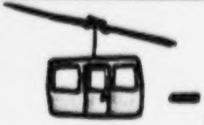
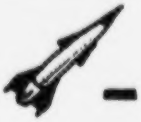
6. ______________

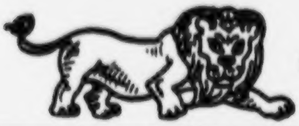


7. ______________

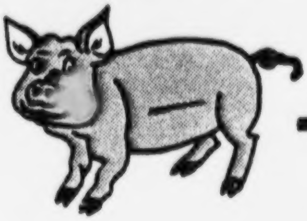
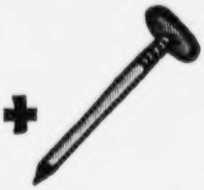

–b
+
RIGHT ONLY
+
– G

8. ______________

 −M + NS +  −ILE +

 −L

9. ______________

S +  − P + 

10. ______________

Score ________

Grade ________

Name ________________

Date ________________

Period ________________

Work Sheet

Activity

1. Classify the items listed below in accordance with their primary electrical power requirements. Use the following categories: (a) DC operation only; (b) AC operation only; and (c) combination device, operating on either AC or DC. List the device in the proper column of the chart provided.

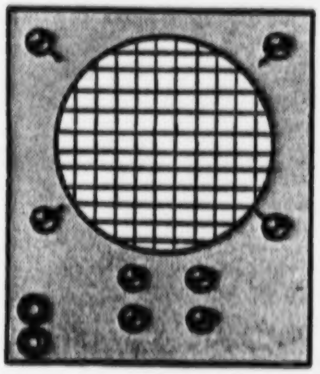
Flashlight
Iron
Universal motor
Automobile
Incandescent lamp
Cordless electric razor
Toy motor
Transformer
Radio
Electric range
Washing machine
Microwave oven
Television
Doorbell
Hearing aid
Food processor
Movie projector
Electric typewriter
Electronic flash unit (for cameras)
Coffee maker
Telephone
Portable radio/tape player
Blow dryer
CB radio—mobile unit

DC operation only	AC operation only	Combination

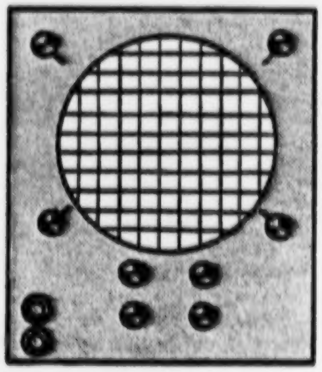
2. Define *alternating current.*

3. Define *direct current.*

4. Draw the appropriate signals or electrial waves on the oscilloscope screens pictured below.



DC Wave



AC Sine Wave

5. Describe the four advantages that alternating current has over direct current.

A.

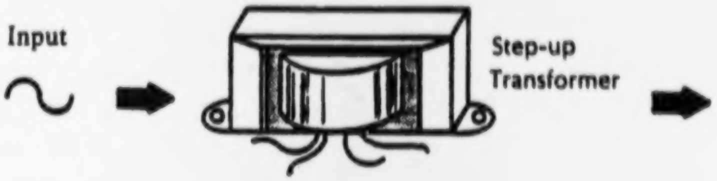
B.

C.

D.

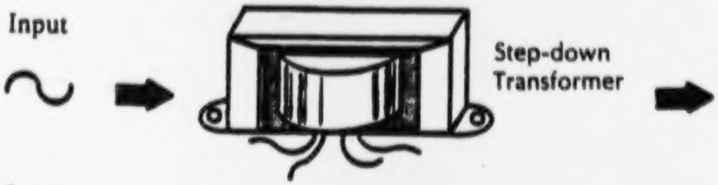
6. Draw the output voltage signals which will be produced by the following devices:

A. Input


Step-up
Transformer

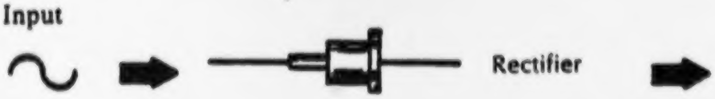
Output ____________________

B. Input


Step-down
Transformer

Output ____________________

C. Input

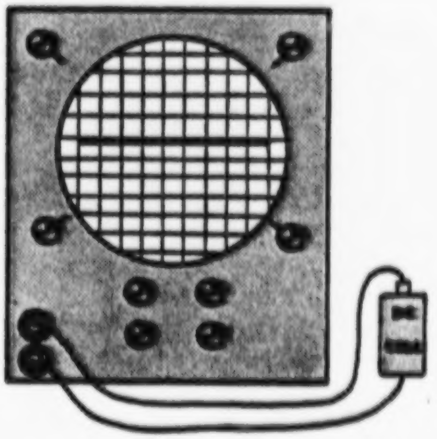


Output ____________________

Informational Handout

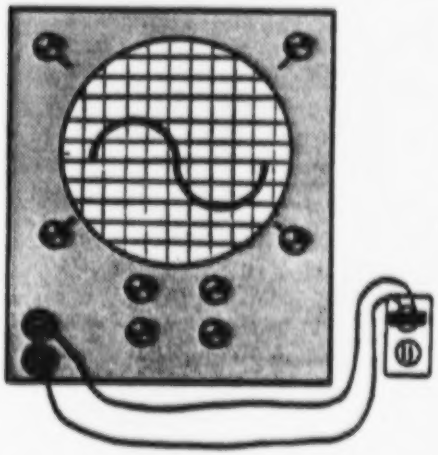
AC and DC Current Characteristics

DC Characteristics



- Direct current flows in only one direction through a circuit.
- The polarity of direct current does not change.
- Direct current usually has a steady or constant value.
- Direct current is used exclusively as a source of energy.

AC Characteristics

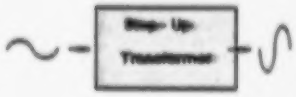


- Alternating current flows in two directions through a circuit, first in one direction, then in the opposite direction.
- The polarity of an alternating current periodically changes.
- An alternating current is continually changing in value; it will increase from zero to a maximum point in either direction and then drop back to zero.
- Alternating current can be used as a source of energy or as an electrical signal—a sound wave, radio wave, or light wave.

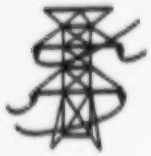
Advantages of AC vs DC Current

1. Alternating current generators are not as complex as direct current generators; they can be constructed in larger sizes and are more economical to operate. Thus, the alternating current generator is easier and cheaper to produce.

2. Alternating current voltage can be stepped-up (increased) or stepped-down (decreased) with very little loss of power by using a transformer.



3. Alternating current is easily converted into direct current by means of a diode or rectifier. This converted alternating current, now direct current, can be used to operate various direct current circuits.



4. Because of the ease by which alternating current is transformed to high voltages, it becomes more efficient to transmit on power lines. Alternating current signals also travel longer distances through the air than direct current signals.

Answer Key
for Unit 16

	T	F		
	1	2	3	4
1.		■		
2.		■		
3.	■			
4.	■			
5.		■		
6.		■		
7.		■		
8.		■		
9.	■			
10.		■		
11.	■			
12.		■		
13.	■			
14.	■			
15.	■			
16.			■	
17.	■			
18.			■	
19.			■	
20.				■
21.				
22.				
23.				
24.				
25.				

	T	F		
	1	2	3	4
26.				
27.				
28.				
29.				
30.				
31.				
32.				
33.				
34.				
35.				
36.				
37.				
38.				
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40.				
41.				
42.				
43.				
44.				
45.				
46.				
47.				
48.				
49.				
50.				

Answer Key
for Unit 16—Continued

Glossary Cryptics

1. Cycle
2. AC/DC
3. Radio wave
4. Sine wave
5. Amplitude
6. Rectification
7. Transformer
8. Alternator
9. Transmission
10. Signal

Activity

1. *Direct current (DC)*

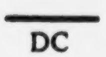
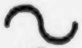
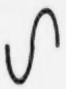
   Flashlight
   Automobile
   Cordless electric razor
   Toy motor
   Hearing aid
   Electronic flash unit
   Telephone
   Portable radio/tape player
   CB radio—mobile unit

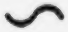
   Alternating current (AC)

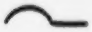
   Iron
   Incandescent lamp
   Transformer
   Electric range
   Washing machine
   Microwave oven
   Doorbell
   Food processor
   Movie projector
   Electric typewriter
   Coffee maker
   Blow dryer

   Combination

   Radio
   Universal motor
   Television

2. Current that changes from zero to some maximum value and then to zero again, then reverses direction and changes from zero to maximum in that direction and then back to zero
3. Current that flows in one direction only and does not reverse itself
4. 
   DC
   
   AC
5. A. Easily transformed up or down
   B. Easy transmission
   C. Easy to rectify to DC
   D. Efficient generation
6. A. 

   B. 

   C. 

Unit 17

Motors and Generators

Title of Unit: Motors and Generators

Time Allocated: Two weeks

Unit Goals

To familarize students with the application and operation of motors and generators and to explore some of the available energy sources and distribution systems

Unit Objectives

The student will be able to do the following:

1. State the purpose and operating principles of the electrical motor and generator.
2. Explain several typical commercial applications of direct current (DC) and alternating current (AC) motors and list four specific causes of motor failure.
3. Identify and compare the variety of modern energy sources which may be used in the generation of electrical power and describe the common kind of distribution system that is used to deliver this power to the consumer.

Evaluation

The student will demonstrate his or her competence in the unit objectives on the basis of performance criteria established by the individual instructors. The criteria may include a combination of written, oral, and laboratory testing procedures.

Instructor's References

Gerrish, Howard H., and William E. Dugger, Jr. *Electricity and Electronics.* South Holland, Ill.: Goodheart-Wilcox Company, Inc., 1980.

Miller, Rex. *Industrial Electricity* (Revised edition). Peoria, Ill.: Chas. A. Bennett Co., 1982.

Shrader, Robert L. *Electronic Communication* (Fifth edition). New York: McGraw-Hill Book Company, 1985.

Overview

This unit can be presented, modified, or omitted, as desired by the instructor, to facilitate individual program needs. If used, it should be introduced with a review of units 6, 15, and 16.

Remember, at this level the instructor is only presenting a rather general overview of the methods which can be used to covert energy to attain either mechanical or electrical power.

Servicing techniques, troubleshooting, maintenance, and specific causes of motor failure are topics which can create interest and which have tremendous practical application.

This unit should conclude with a stimulating discussion on and demonstration of the types of energy sources and distribution systems that are currently being used and those that are being developed to meet society's future power consumption needs.

Suggested Presentation Hints/Methodology

Use this unit as a basic guideline for presenting the curriculum; however, note the following:

1. Allow the class to examine and investigate the construction of a simple motor and generator prior to discussing the basic principles of their operation. If possible, use a large cutaway model of each to enhance students' comprehension of the basic parts and their general locations.
2. When appropriate, compare the applications of alternating current and direct current motors and generators.
3. Introduce the class to the topic of power plants and their operation. This topic can be technically informative or controversial. Some interesting classroom activities may be developed. Specifically, the topics of nuclear power plants and reactors and future needs usually evoke fascinating class discussions.
4. Do not overlook the local power company as an excellent resource for support materials on the topics of motors, generators, power plants, distribution systems, alternative power sources, and careers. These companies often supply interested educators with films, filmstrips, videotapes, posters, work sheet masters, guest speakers, and a variety of other media-related assistance.

Supplemental Activities and Demonstrations

The following supplemental activities and demonstrations are suggested for use in presenting the curriculum:

1. Have a small group from the class develop a visual aid that depicts how electricity is created. Begin the diagram with the arrival of the fuel at the power plant and continue through the production of electricity and its distribution to the consumer.
2. Write to the following informational sources for data on solar energy. Have several students write and share their materials.

National Solar Heating and Cooling
Information Center
P.O. Box 1607
Rockville, MD 20850

U.S. Department of Energy
Technical Information Center
P.O. Box 62
Oak Ridge, TN 37830

Instructional Unit Contents

1. Unit Outline (overhead)
2. Pretest and Post-test (keyed)
3. Technical Glossary
4. Work Sheet (vocabulary)—Word Decoding
5. Work Sheet—DC Motors and Electric Generators
6. Activity
7. Informational Handout (Operation of a Simple DC Motor)
8. Informational Handout (The Basics of DC and AC Generators)
9. Answer Key for Unit 17

Unit 17

Motors and Generators

(Lecture Outline)

A. Conversion of Electrical Energy to Mechanical Energy

B. Internal Construction of a Simple Direct Current Motor

C. Fundamental Principles of Motors

D. Servicing and Repairing of Motors
  1. Causes of motor failures
    a. Dirt
    b. Moisture
    c. Friction
    d. Vibration
  2. General maintenance procedures

E. Conversion of Mechanical Energy to Electrical Energy
  1. Direct current generators
  2. Alternating current generators

F. Generation and Distribution of Electricity
  1. Power plant facilities
    a. Geothermal
    b. Fossil fuel
      (1) Gas
      (2) Oil
      (3) Coal
    c. Hydroelectric
    d. Nuclear
    e. Other (solar and wind)
  2. Distribution systems
    a. Transmission line
    b. Substation

Test number ________

Examination for Unit 17

Motors and Generators

Write your answers to the questions on the answer sheet. Fill in the box that corresponds to the correct answer to the question. Each question has only one correct answer.

1. A generator is used to convert electrical energy into mechanical or rotational energy. (T-F)
2. Direct current motors and generators are very similar in construction. (T-F)
3. The rotating electromagnet used in a direct current motor is called the field magnet. (T-F)
4. All electric motors operate on the principle of magnetic or electromagnetic attraction and repulsion. (T-F)
5. The armature windings of a direct current motor are connected to the power source by a commutator and a set of brushes. (T-F)
6. At present, all of the world's electrical energy is produced by generators. (T-F)
7. Alternating current generators are also called amplifiers. (T-F)
8. Electric generators operate on the principle of electromagnetic induction. (T-F)
9. A generator produces electricity by means of a stationary magnetic field and a revolving coil or by means of a rotating magnetic field and a stationary coil. (T-F)
10. Direct current generators produce an electric current which flows first in one direction, stops, and then flows in the opposite direction. (T-F)
11. An electric motor cannot be damaged by overoiling. (T-F)
12. Friction and dirt are major causes of motor failure and overheating. (T-F)
13. Power plants are operated with either fossil fuels or hydropower. (T-F)
14. A substation is the site where electricity can be switched, routed, and transformed as required. (T-F)
15. The size of an electric motor is given in terms of watts or horsepower. (T-F)
16. The small blocks of carbon which contact either the commutator or slip rings of a generator are called:

    1. Brooms
    2. Wipers
    3. Rotors
    4. Brushes

17. The frequency of the alternating current power generated in most parts of the United States is:

    1. 50 hertz
    2. 55 hertz
    3. 60 hertz
    4. 120 hertz

18. The rotor of an alternating current generator has a function similar to the ______ of a direct current generator.

    1. Field magnet
    2. Armature
    3. Commutator
    4. Brushes

19. The direct current motor does not contain a(n):

    1. Brush set
    2. Set of slip rings
    3. Armature
    4. Field magnet

20. If the ends of an armature coil are connected to a set of slip rings and the armature is rotated within a magnetic field:

    1. An alternating current will be generated.
    2. The voltage produced will change in both value and direction.
    3. Direct current will be generated.
    4. Both 1 and 2.

21. The armature of an electric motor rotates because it is both attracted and repelled by the poles of the field magnet. The device that controls the timing of the attracting and repelling force is called the:

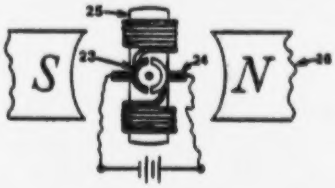
    1. Timing switch
    2. Commutator
    3. Armature
    4. Slip ring

22. Large alternating current generators, such as those used in power plants, can be turned by:

    1. Steam turbines
    2. Diesel engines
    3. Hydroturbines
    4. All of the above

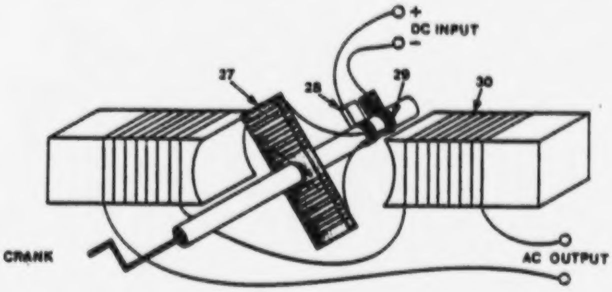
For questions 23 through 26 identify the parts of the direct current motor pictured below.

23. ______________________
24. ______________________
25. ______________________
26. ______________________

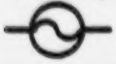


For questions 27 through 30, identify the parts of the alternating current generator pictured below.

27. ______________________
28. ______________________
29. ______________________
30. ______________________



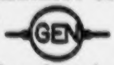
Technical Glossary

Alternating current (AC) generator—An electromechanical device which uses a revolving rotor, a stationary stator, and a slip ring brush set to produce alternating current electricity. Alternating current generators are also called alternators. The symbol for an alternating current generator is  .

Armature—The revolving part of a generator or motor. In a generator the voltage is produced within the coils of the armature. In a motor, the armature coils are attracted to and repelled from the field poles, causing motion.

Brushes—A set of small conducting rods, usually carbon or copper, which are used to make a sliding contact with the commutator or slip rings.

Commutator—A ring of copper segments, insulated from each other, that are used as part of the sliding contact between the brushes and the armature of a motor or generator.

Direct current (DC) generator—An electromechanical device which uses a revolving armature, a stationary field magnet or electromagnet, and a commutator brush set to produce direct current electricity. The symbol for a direct current generator is  .

Distribution system—The power system which routes the electrical energy generated at the power plant to the consumer. The system includes long-distance transmission lines, step-down transformers, feeder lines, a substation, distribution lines, and distribution transformers.

Field magnet—Either a permanent magnet or an electromagnet used to provide the magnetic field that is required in a motor or generator.

Fossil fuels—Fuels such as coal, petroleum, natural gas, and refined petroleum products (gasoline, diesel oil, and fuel oil) which are burned to produce heat energy.

Geothermal energy—A natural source of energy produced when water seeps into the ground, is heated by the earth's hot magma core, and then rises to the surface as steam. Geysers, steam vents, and fumaroles are examples of geothermal activity.

Horsepower—A method of rating the power or "strength" of a motor. One horsepower is equivalent to lifting 550 pounds (249.7 kilograms) 1 foot (30.5 centimetres) in 1 second.

Hydropower—The energy provided by running or falling water.

Motor—A machine that converts electric energy into mechanical or rotational energy. Motors use the magnetic forces of attraction and repulsion to cause an armature to rotate.

Nuclear power—A modern source of energy which uses the principles of atomic fission (the breaking of the atom) to produce tremendous amounts of heat. This heat is generally used to convert water into steam.

Power plant—A large generating facility used to produce the electric energy required by several cities or a section of the state. Power plants may use fossil fuels, hydropower, nuclear energy, geothermal energy, or other energy sources to supply power to turbines. The turbines turn generators, which produce electricity.

Rotor—The rotating part of an alternating current generator or alternator. The rotor supplies a rotating magnetic field within the alternator.

Slip rings—Two copper rings which, along with the brushes, provide a sliding contact with the rotor of an alternator or a generator.

Stator—The stationary coils of an alternating current generator.

Substation—Part of an alternating current power distribution system in which the high voltage energy from the transmission lines is changed to a usable voltage or current value. The substation includes transformers, switches, circuit breakers, and other equipment.

Transmission lines—High-tension power lines which are usually strung between steel towers and which carry the high-voltage, low-current alternating current energy from the power plant to the substation.

Turbine—A finned device, similar to a fan, which is connected to the rotor of the power plant generator. When steam or water is forced into the turbine, the turbine is forced to spin, thus turning the rotor of the generator.

Score ________

Grade ________

Name ________________

Date ________________

Period ________________

Work Sheet

Word Decoding

The words below have little meaning until they are decoded. Each letter actually represents another letter in the alphabet. The example will get you started in decoding the other scrambled words listed on the work sheet.

Example:

A. DYGYVH — A. STATOR

1. CVYVH — 1. ________
2. GHCGYKHR — 2. ________
3. YKHMOPR — 3. ________
4. AVCCKYGYVH — 4. ________
5. WRPRHGYVH — 5. ________
6. WRVYBRHCGI — 6. ________
7. DKMDYGYOVP — 7. ________
8. XORIL CGWPRY — 8. ________
9. MHKDBRD — 9. ________
10. YHGPDCODDOVP IOPR — 10. ________

Score ________

Grade ________

Name ____________________

Date ____________________

Period ____________________

Work Sheet

DC Motors and Electric Generators

1. A device which has the ability to change electrical energy into mechanical or rotational energy is called a ______.

1. ____________________

2. A motor contains at least ______ interacting magnetic fields.

2. ____________________

3. The armature in a motor rotates as a result of ______ attraction and repulsion.

3. ____________________

4. List the four basic parts of a direct current motor.

4A. ____________________

4B. ____________________

4C. ____________________

4D. ____________________

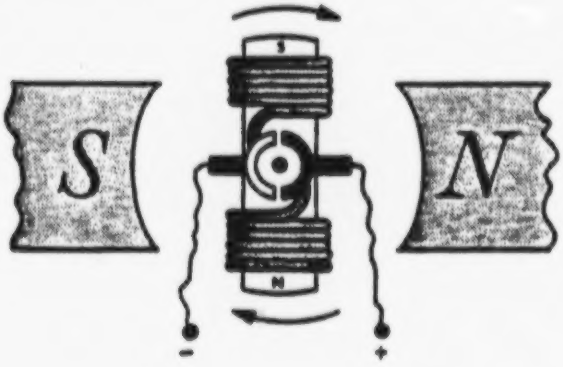
5. The _____ and _____ of a direct current motor form a rotating switch which controls the direction of current flow through the armature.

5A. ____________________

5B. ____________________

6. Explain what occurs when the current flow through the armature reverses direction.

7. Briefly describe the "motor action" occurring in the drawings below. Pay particular attention to the location and effect of the commutator.



7A. ____

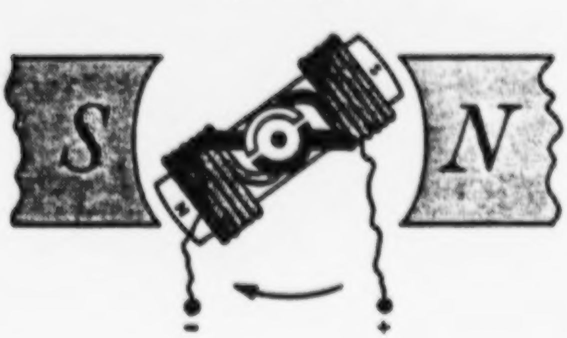
____

____

____

____

____



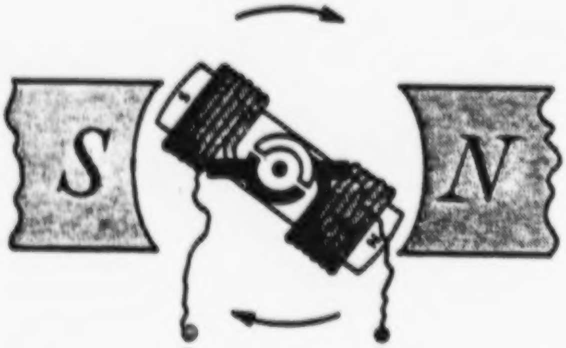
7B. ______________________________

____

____

____

____



7C. ______________________________

____

____

____

____

8. List four common causes of motor failure.

8A. ____________________

8B. ____________________

8C. ____________________

8D. ____________________

9. Explain why friction is so damaging to an electric motor. Suggest a way that friction can be reduced to an acceptable level.

10. What is the main physical difference between a simple alternating current generator and a direct current generator?

11. List the three basic requirements that are necessary to generate voltage.

11A. ____________________

11B. ____________________

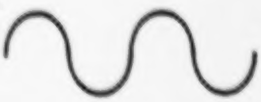
11C. ____________________

12. Identify the generator output waves pictured below.

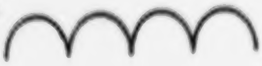
12A. ________________________

12B. ________________________

A.



B.



13. The ______ in the direct current generator acts as a rotating switch, allowing the output current to flow in only one direction.

13. ________________________

14. The _____ in an alternator provides a strong electromagnetic field which, when rotated, generates a voltage in the stationary _____ windings.

14A. ________________________

14B. ________________________

15. List five factors which will affect the output of a generator. In each case indicate how the output will be affected.

Score ________ Name ____________________

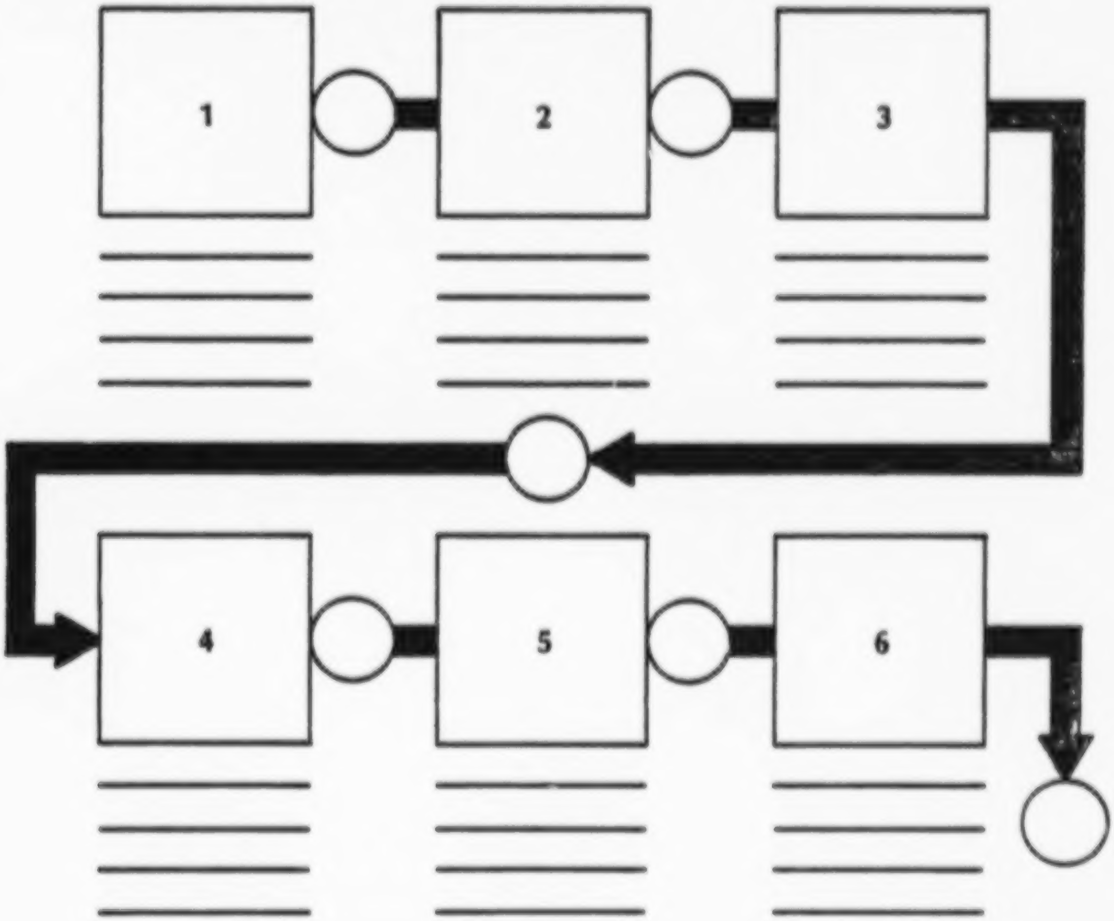
Grade ________ Date ____________________

Period ____________________

Work Sheet

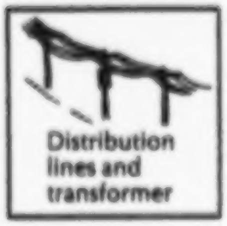
Activity

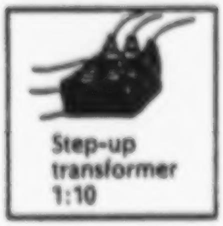
1. Make a photocopy of the next page; then cut out the illustrations and place each element in proper sequence to form a complete alternating current power distribution system. In the blank circles to the right of each element, insert the cutout of the approximate voltage. Begin with the production point and conclude with the energy user. Write a brief description of what happens at each location.

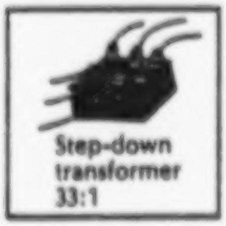


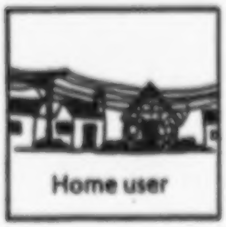
2. Describe in detail why alternating current power systems are needed.

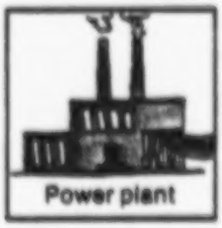
Illustrations

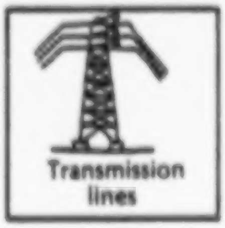

Distribution
lines and
transformer


Step-up
transformer
1:10


Step-down
transformer
33:1




Power plant


Transmission
lines

4,000 V

132,000 V

STOP

132,000 V

120/240 V

13,200 V

Informational Handout

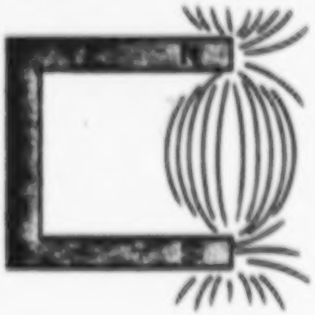
Operation of a Simple DC Motor

An electric motor converts electrical energy into mechanical or rotational energy. The first crude electric motor was developed in 1831 by an American, Joseph Henry. Today, electric motors are used in hundreds of home appliances and thousands of pieces of industrial equipment.

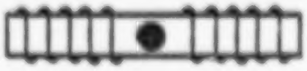
Electric motors operate on the principle of magnetic repulsion and attraction; that is, like poles repel and unlike poles attract. In its simplest form, a direct current motor contains two interacting magnetic fields, one stationary and one which rotates. These two interacting fields cause the motor to produce torque or rotational energy.

The basic parts of a direct current motor are as follows:

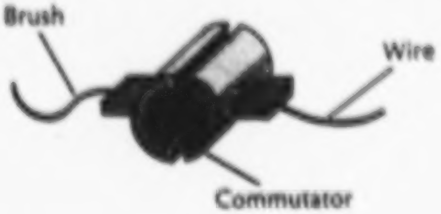
- *Field magnet:* A stationary magnetic field provided by either a permanent magnet or an electromagnet.



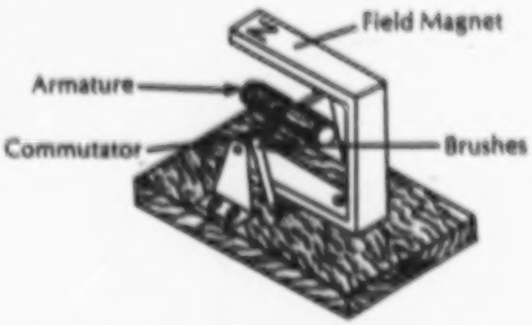
- *Armature:* An electromagnet wound on a shaft or axle. The armature revolves within the field magnet.



- *Commutator and brushes:* The commutator is made up of at least two segments of copper, which are insulated from each other and are located on the armature shaft. Connected to each commutator segment is one end of the wire which makes up the armature coil. The brushes, which are made of either carbon or copper, ride against the commutator, forming a rotating connection.

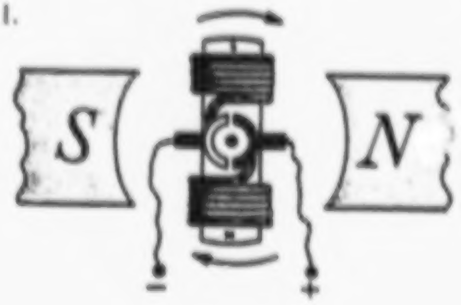


Simple DC Motor



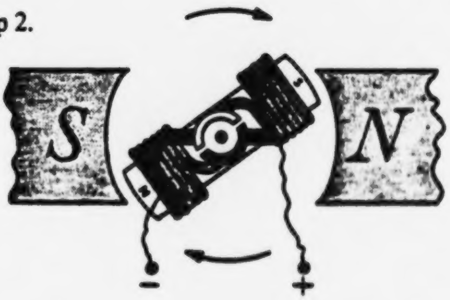
The key to the operation of a direct current motor is the armature/commutator action. Recall that the armature is basically a coil of wire which forms an electromagnet when current flows through it. The direction of current flow through the coil will determine the north and south poles of the electromagnet. The commutator and brushes, in turn, will route the current through the armature coils in the proper direction to cause the armature to be attracted to or repelled from the proper field pole at the proper time.

Step 1.



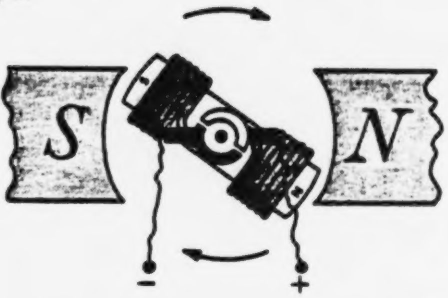
When a battery is connected to the brushes and commutator, as shown, the armature coil produces a magnetic field with a south pole at the top of the coil and a north pole at the bottom of the coil. In this case, the armature poles will be attracted toward the field magnet poles in a clockwise direction.

Step 2.



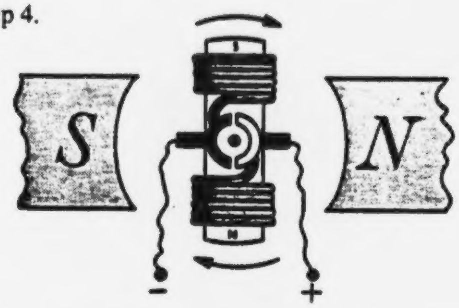
As the armature approaches the horizontal position, its magnetic polarity must be changed to prevent the armature from being trapped and stopped by the strong field magnet's north pole. If you look closely at the commutator, you will notice that the gap between the commutator segments is approaching the brushes. Once the brushes override the gap, the armature field is momentarily turned off, allowing the armature to rotate past the field poles.

Step 3.



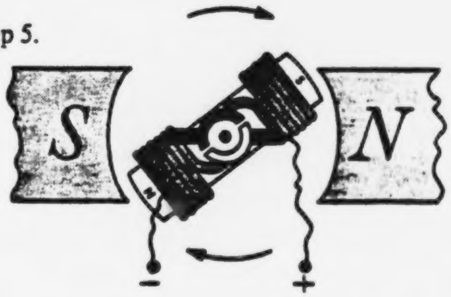
When the brushes touch the next commutator segment (the positive brush is now contacting the segment formerly touched by the negative brush), the polarity of the armature is reversed. The poles of the armature are now repelled by the field magnet.

Step 4.

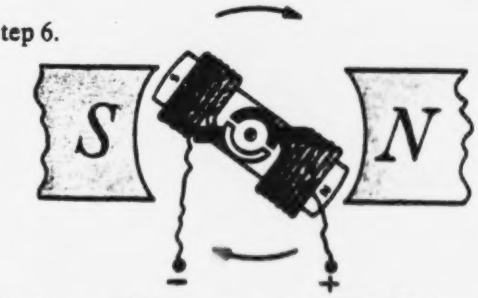


As the armature continues to rotate, the armature's electromagnet and the field magnet begin to attract each other and rotation continues.

Step 5.



Step 6.



In the space below, try to complete the descriptions for steps 5 and 6 of the motor's operation.

Finally, the armature will return to its starting position, as shown in Step 1, completing one revolution.

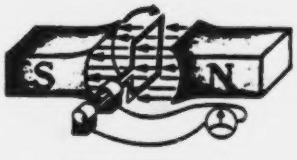
Informational Handout

The Basics of DC and AC Generators

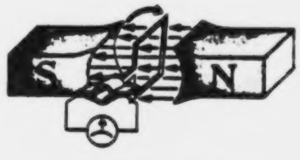
Generators convert mechanical energy into electrical energy by a process known as electromagnetic induction; that is, by either moving a coil of wire through a magnetic field or by holding the coil stationary and moving the magnetic field. Direct current generators produce pulses of electricity which always have the same polarity, either positive or negative. Alternating current generators produce pulses of electricity which periodically change polarity, having both a positive and negative portion.

The difference between the two generators is in the direction that the generated current flows through the coil. In an alternating current generator (alternator), the ends of the coil loop are connected to a set of slip rings, which permit current to flow first in one direction (as the loop moves past the north field pole) and then to reverse and flow in the opposite direction (as the loop moves past the south field pole). Thus, the potential of the voltage present on the brushes changes first from plus to minus and then from minus to plus.

The direct current generator uses a commutator instead of slip rings as the end connection of the armature loop. The commutator causes the current to flow in only one direction from the coil. The half of the loop passing the north field pole will always produce one potential (negative), while the half of the loop which passes the south field pole will always produce the opposite potential (positive). Thus, the potential of the voltage present on the brushes is always the same—one positive and one negative.

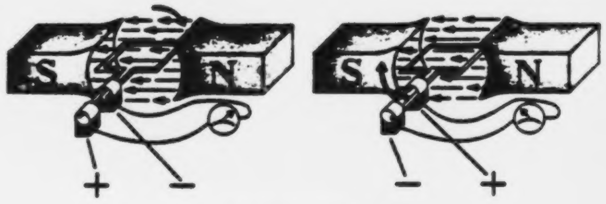


AC Generator

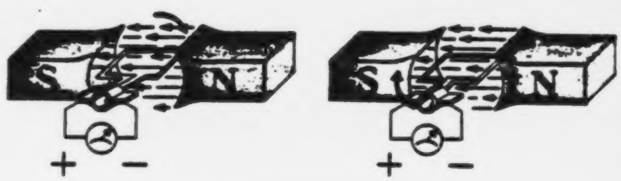


DC Generator

Note: Meter center is zero.



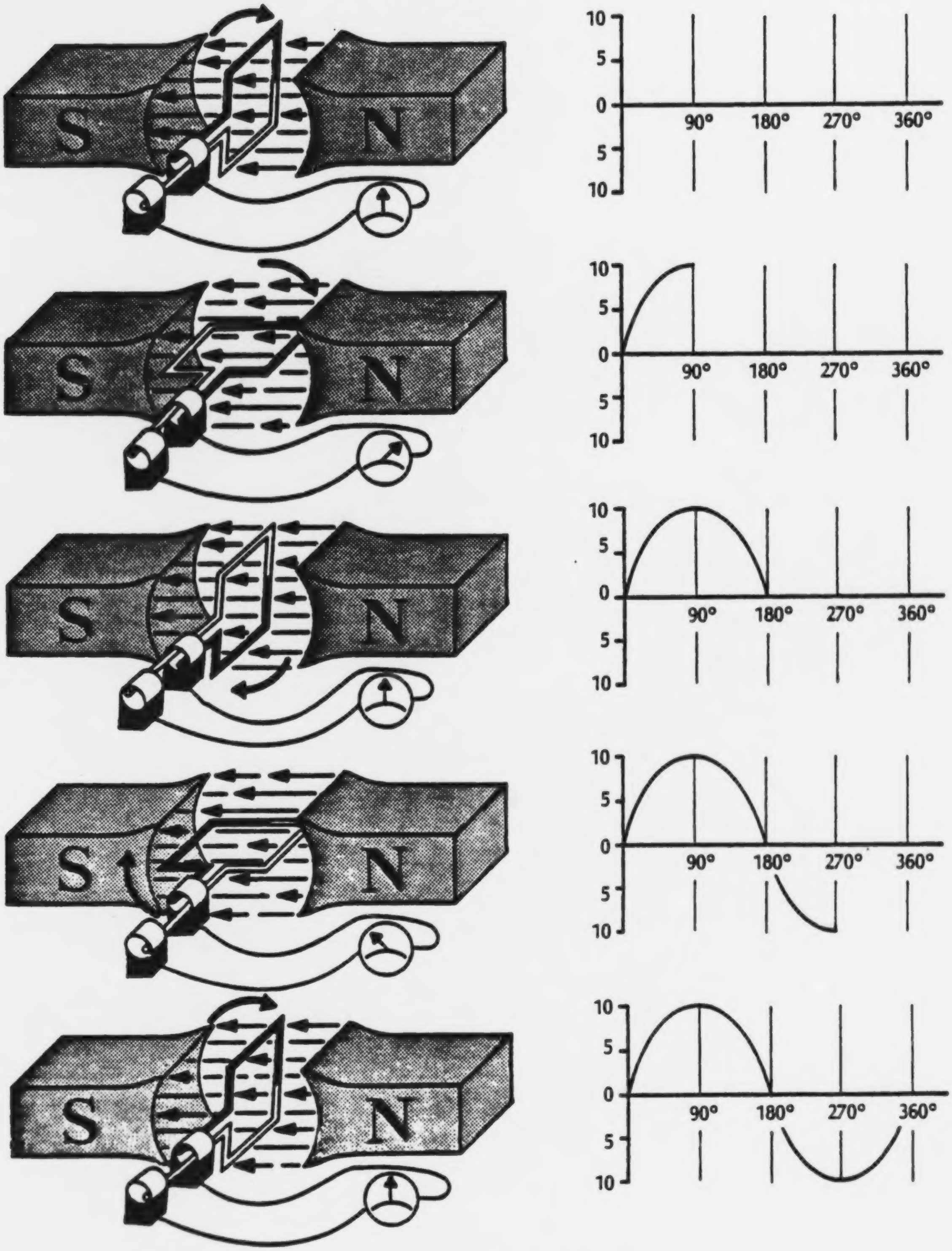
AC Generator



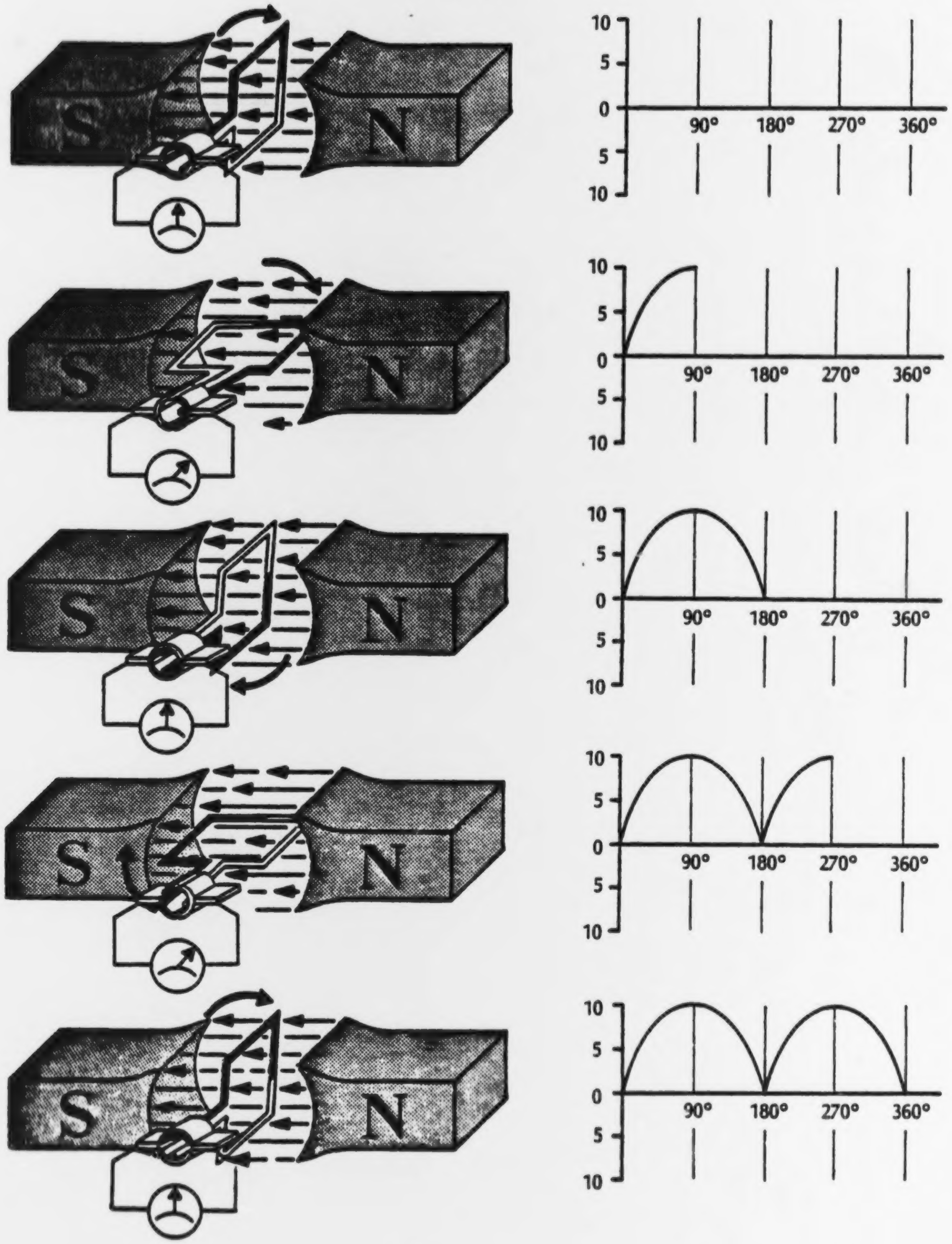
DC Generator

AC and DC Generation:

AC Generator


S
N
10
5
0
5
10
90°
180°
270°
360°

DC Generator


S
N
10
5
0
5
10
90°
180°
270°
360°

Answer Key
for Unit 17

	T	F		
	1	2	3	4
1.		■		
2.	■			
3.		■		
4.	■			
5.	■			
6.		■		
7.		■		
8.	■			
9.	■			
10.		■		
11.		■		
12.	■			
13.	■			
14.	■			
15.	■			
16.				■
17.			■	
18.	■			
19.		■		
20.				■
21.		■		
22.				■
23.	Commutator			
24.	Brush			
25.	Armature			

	T	F		
	1	2	3	4
26.	Field pole			
27.	Rotor			
28.	Brush			
29.	Slip ring			
30.	Stator			
31.				
32.				
33.				
34.				
35.				
36.				
37.				
38.				
39.				
40.				
41.				
42.				
43.				
44.				
45.				
46.				
47.				
48.				
49.				
50.				

Word Decoding

1. Motor
2. Armature
3. Turbine
4. Commutator
5. Generator
6. Geothermal
7. Substation
8. Field magnet
9. Brushes
10. Transmission line

DC Motors and Electric Generators

1. Motor
2. Two
3. Magnetic

4A. Armature
4B. Field magnet
4C. Commutator
4D. Brushes
5A. Brushes
5B. Commutator

6. The polarity of the armature is reversed and the poles of the armature are repelled by the field magnets; the armature continues to rotate.
7. In Figure A, current flow in the armature polarizes the armature, and the upper pole is repelled from the S pole of the field magnet and is attracted toward the N pole of the field magnet. The bottom of the armature is affected in the same manner.

   In Figure B, the clockwise rotation of the armature causes rotation of the two commutator segments under the brushes. The centrifugal force of rotation carries the upper segment into contact with the right-hand brush and the lower segment into contact with the left-hand brush, thereby reversing the direction of current flow in the armature and magnetizing it in the direction shown in Figure C. Now, we have the same conditions we had at Figure A and are ready to continue.

Answer Key for Unit 17—Continued

8A. Worn brushes
8B. Frozen or worn bearings
8C. Shorted or open field or armature windings
8D. Worn commutator
9. Friction causes heat, and heat will melt solder connections at the commutator or might short through the insulation between windings or melt a winding to cause an open circuit. Frequent cleaning and oiling can reduce friction.
10. A direct current generator uses a commutator; an alternating current generator has slip rings.
11A. Magnetic field
11B. Conductor
11C. Movement of the conductor in the field
12A. Alternating current
12B. Pulsing direct current
13. Commutator
14A. Rotor
14B. Stator
15A. An increase in speed will increase voltage and frequency.
15B. Added magnetic poles provide higher voltage for less speed.
15C. More armature windings will yield higher voltage for less speed.
15D. Stronger fields will yield higher voltage.
15E. Slip rings will produce alternating current; commutator segments will produce direct current.

Activity

1-1. Power plant; 13,200V
1-2. Step-up transformer; 132,000V
1-3. Transmission lines; 132,000V
1-4. Step-down transformer; 4,000V
1-5. Distribution lines; 120/240V
1-6. Home user; stop
2. (Answers will vary.)

Unit 18

Low-Voltage Signal Devices

Title of Unit: Low-Voltage Signal Devices

Time Allocated: Two weeks

Unit Goal

To increase the student's ability to comprehend low-voltage, low-current circuits, including knowledge of the special techniques for wiring signal circuits and a profile of basic security alarm systems

Unit Objectives

The student will be able to do the following:

1. Identify the five basic components that are required for a typical signal circuit: power source, bell transformer, push-button switch, wire, and a signal device.
2. Demonstrate an ability to wire signal circuit components in series, in parallel, or in combination, as directed.
3. Distinguish between a signal-type circuit and a power-type circuit and explain the detection, control, and signaling operations of a typical security alarm system.

Evaluation

The student will demonstrate his or her competence in the unit objectives on the basis of performance criteria established by the individual instructors. The criteria may include a combination of written, oral, and laboratory testing procedures.

Instructor's Reference

Miller, Rex. *Industrial Electricity* (Revised edition). Peoria, Ill.: Chas. A. Bennett Co., 1982.

Overview

The primary purpose of this unit is to make students aware of the reasons that signal circuits are treated differently from power circuits.

To accomplish this purpose, first introduce the students to the essential ingredients that compose a signal circuit. Second, modify the circuitry of the signal device so that the controls or bells are placed in series (parallel). This exercise will broaden the students' technical understanding of typical variations in basic low-voltage, low-current circuits.

The final topic of this unit is intended to generate enthusiasm and to be informative. Security alarm systems have emerged as a giant allied field to electronics, and practical application is an important competency.

The activities in this unit should be extremely exciting to students if they are presented in a positive manner. The examination for this unit is of a practical nature and will require more time to grade.

Suggested Presentation Hints/Methodology

Use this unit as a basic guideline for presenting the curriculum; however, note the following:

1. Familiarize the students with the applications of low-voltage and low-current systems in the home. Point out that the telephone, doorbell, intercom, security alarm, antenna, smoke detector, and so on represent this type of system and that their wiring requires the knowledge of some special regulations, as specified in the *National Electrical Code.*
2. Mention to the class that annunciators are usually found in signal systems that are used by many callers who must wait for service or assistance. Give the two main functions of such devices: They signal when activiated, and they indicate where the signal was originated. These systems also have a means to reset, thereby returning the unit to its normal static position.
3. When discussing security alarm systems and the techniques of providing burglar protection, have the students examine some floor plans to determine vulnerable entry points. Have them "think like a burglar" and check the premises from this viewpoint. Once they have analyzed the situation, they are ready to develop an alarm system that could realistically foil would-be intruders.

Supplemental Activities and Demonstrations

The following supplemental activities and demonstrations are suggested for use in presenting the curriculum:

1. An activity with bells, switches, and so on that can promote the students' comprehension and challenge their imagination involves two phases. First, hand out a simple floor plan of a rural school with three rooms. The problem is for them to draw in the wiring that will allow each room to have its own bell; however, all bells are to be controlled by a central switch. The second phase involves construction of the bell circuit, which can be wired and tested on a mock-up-type board.
4. The students should be advised that the wiring of signal circuits is generally done by electricians. A description of this specific occupation is very helpful and informative for the students.

Instructional Unit Contents

1. Unit Outline (overhead)
2. Pretest and Post-test (keyed)
3. Technical Glossary
4. Work Sheet (vocabulary)—Spelling Puzzle
5. Work Sheet—Series, Parallel, and Combination Circuit Wiring of Signal Devices
6. Activity
7. Informational Handout (Home Security Systems)
8. Answer Key for Unit 18

Unit 18

Low-Voltage Signal Devices

(Lecture Outline)

A. Description of a Signal Circuit
   1. Bell transformer
   2. Conductor
   3. Push-button switch
   4. Signal device

B. Applications of Signal Circuits
   1. Basic series circuitry
   2. Basic parallel circuitry
   3. Combination circuitry

C. Security Alarm Devices
   1. Operation
   2. Installation
   3. Varieties

Test number ________

Examination for Unit 18

Low-Voltage Signal Devices

Write your answers on this examination paper. When answering the matching problems, record the letter corresponding to your choice in the appropriate space at the right-hand side of the page.

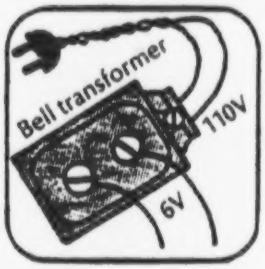
Matching:

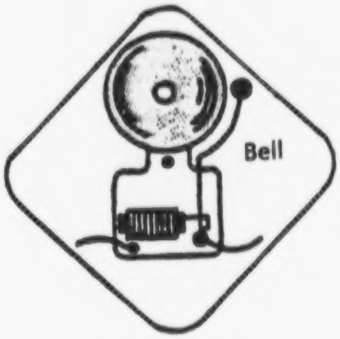
1. A device used to change 117V alternating current to 6V or 12V alternating current
2. A circuit which contains more than one path for current flow
3. A material which allows free movement or flow of electrons
4. A noisemaking device, such as a bell or siren
5. The "sensing" device in an alarm system
6. A type of switch which is activated only as long as pressure is applied
7. A circuit which contains only one path for current flow
8. The "brain" or central unit of an alarm system
9. A type of alarm sensor which projects an invisible field of inaudible waves
10. A circuit which contains both series and parallel sections

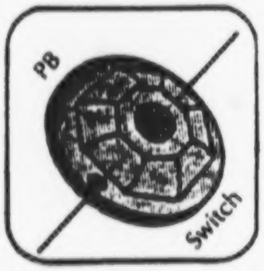
A. Series
B. Control unit
C. Conductor
D. Parallel
E. Signal device
F. Ultrasonic
G. Compound
H. Light beam
I. Toggle
J. Combination
K. Loop
L. Bell transformer
M. Detector
N. Push-button
O. Processor

1. ________
2. ________
3. ________
4. ________
5. ________
6. ________
7. ________
8. ________
9. ________
10. ________

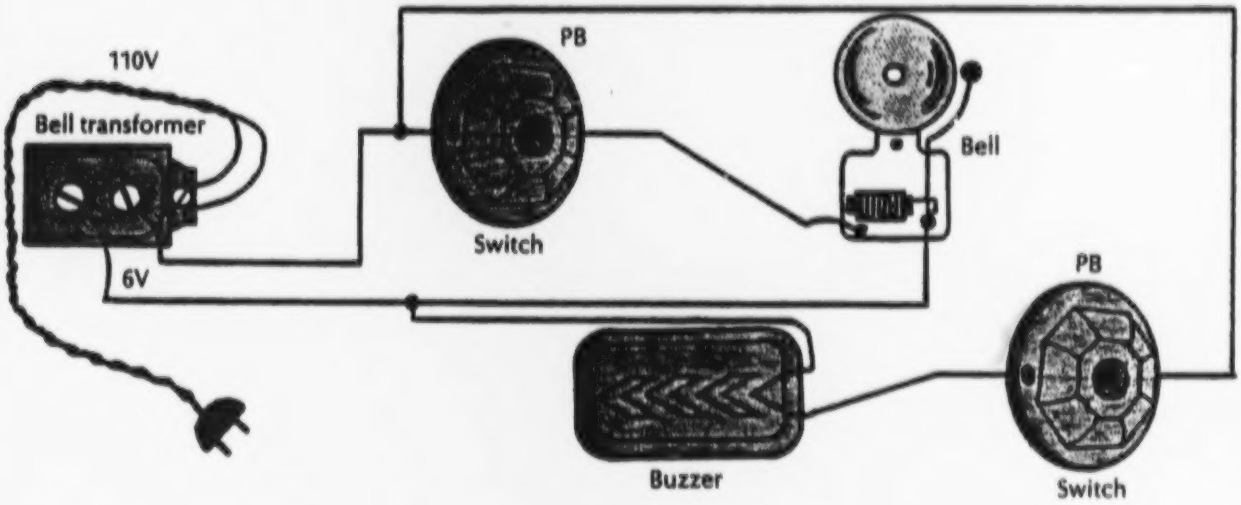
11. Connect the signal circuit components below into a series circuit.







12. Draw the schematic diagram which corresponds to the circuit pictured below.


110V
Bell transformer
6V
PB
Switch
Bell
PB
Buzzer
Switch

Technical Glossary

Alarm control unit—The "brain" or central unit in an alarm system. The alarm control monitors the various detectors in the system and activates the alarm or signal device if the protection circuit is interrupted or violated. A typical control contains an on/off switch, status indicators, time delays, power supplies, and stand-by batteries.

Alarm detector—The part of an alarm system which senses entry or movement in the protected area. The simplest detector is a switch; other common detectors are magnetic switches, pressure sensors, and light beams.

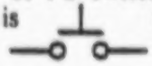
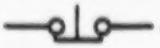
Bell transformers—A small transformer, with built-in overload and short protection, which will convert 117V to 6V or 12V for the operation of doorbells, buzzers, or chimes.

Combination circuit—A circuit consisting of one or more series and parallel paths.

Conductor—Any material through which electric current flows easily, such as a piece of copper wire.

Light beam alarm—A common type of alarm or signaling circuit which will cause a signal device to sound if the light beam is broken.

Parallel circuit—A circuit which provides two or more paths for current flow; sometimes referred to as a shunt or branch circuit.

Push-button switch—A spring-loaded switch which is activated only as long as the button is held in the down position. There are basically two types of PB switches—normally open (NO) and normally closed (NC). The symbol for the PBNO is  and the symbol for the PBNC is .

Series circuit—A circuit which has only one path for current flow. Series circuit components are connected in a line, one after the other.

Signal device—A noise-making device used to alert, notify, or gain attention. Common signal devices are bells, buzzers, horns, and sirens.

Ultrasonic alarm—A "motion detector" alarm which sets up an invisible field of inaudible waves. If the wave pattern is disturbed or interrupted by movement of any kind, the alarm is triggered.

Score ________ Name ______________________

Grade ________ Date ______________________

Period ______________________

Work Sheet

Spelling Puzzle

Write the correctly spelled word in the space provided to the right, as shown in the example below.

A. (example) (exhample) (xample) A. EXAMPLE

1. (cuntrol) (controll) (control) 1. ______________

2. (circuit) (circut) (sircut) 2. ______________

3. (beem) (beam) (beme) 3. ______________

4. (allarm) (alarm) (elarm) 4. ______________

5. (siginal) (signel) (signal) 5. ______________

6. (switch) (swich) (swetch) 6. ______________

7. (divice) (divise) (device) 7. ______________

8. (ditectar) (detecter) (detector) 8. ______________

9. (conducter) (kinducter) (conductor) 9. ______________

10. (ceries) (series) (siries) 10. ______________

11. (parallel) (parrallel) (pareiel) 11. ______________

12. (tranformer) (transformar) (transformer) 12. ______________

13. (lite) (light) (liht) 13. ______________

14. (combenation) (combinasion) (combination) 14. ______________

15. (ultrasonic) (ultresonic) (ultrasonik) 15. ______________

Score ________ Name ____________________

Grade ________ Date ____________________

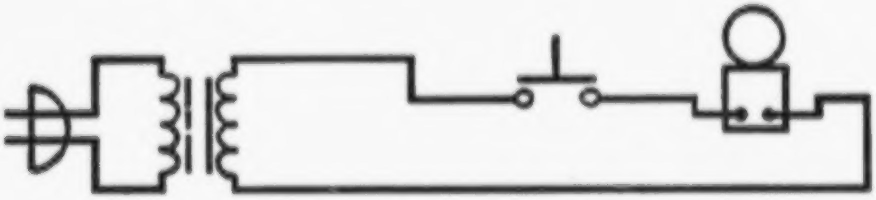
Period ____________________

Work Sheet

Series, Parallel, and Combination Circuit Wiring of Signal Devices

Use the cutouts on the attached sheet to "construct" the circuits described below. Arrange the cutouts to form series, parallel, and combination circuits. Draw in interconnecting lines to represent the conductors. Make sure that each circuit includes the four elements of a complete electrical circuit: supply, control, load, and conductor.

1. Assemble the circuit described in the schematic diagram below.

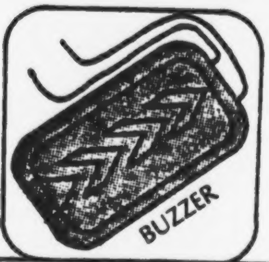


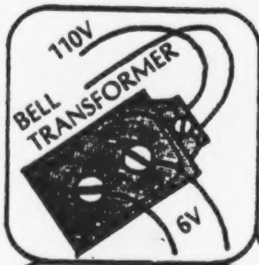
2. Is the circuit in Item 1 a series, parallel, or combination circuit?

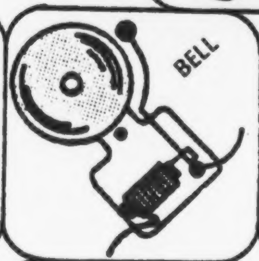
3. Design a buzzer circuit that uses a 110V source, a bell transformer, and two push-button switches. Wire the circuit in such a way that pushing either switch will activate the buzzer. Label the switches as a front door switch and a backdoor switch.

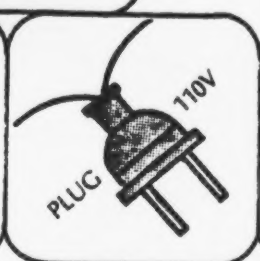
4. Would the switching circuit in Item 3 be considered a series, parallel, or combination circuit?

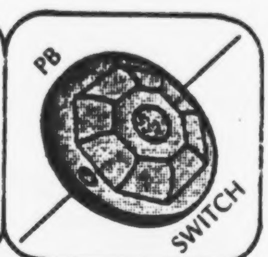
5. Design a combination circuit having one series and one parallel switching branch. Use three switches, two bells, one bell transformer, and a 110V source. If any of the switches is operated, a bell must sound.

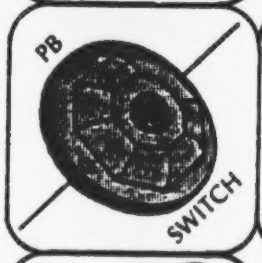

BUZZER

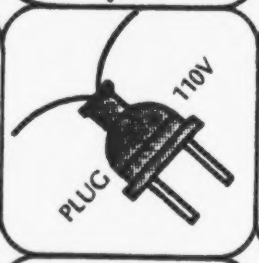

110V
BELL TRANSFORMER
6V

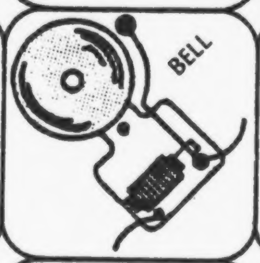

BELL

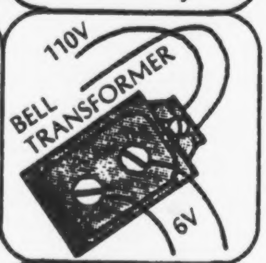

110V
PLUG

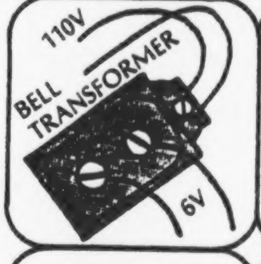

PB
SWITCH

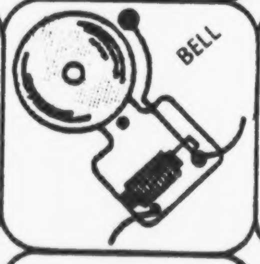

PB
SWITCH

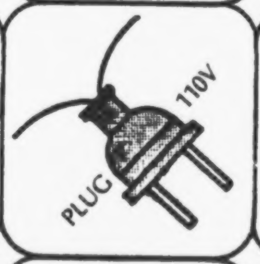

110V
PLUG

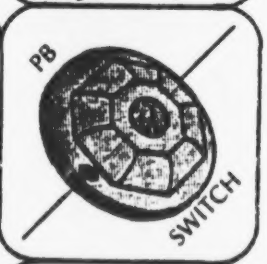

BELL

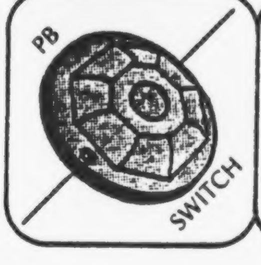

110V
BELL TRANSFORMER
6V

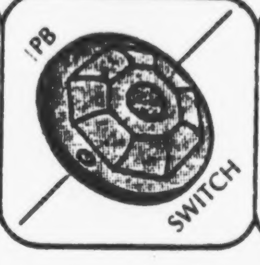

110V
BELL TRANSFORMER
6V

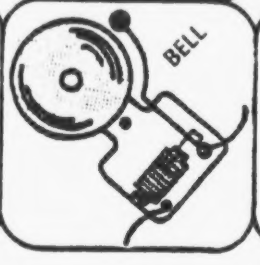

BELL

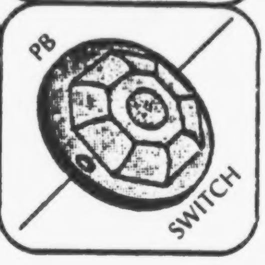

110V
PLUG


PB
SWITCH


PB
SWITCH


PB
SWITCH


BELL


PB
SWITCH

Score ________

Grade________

Name ______________________

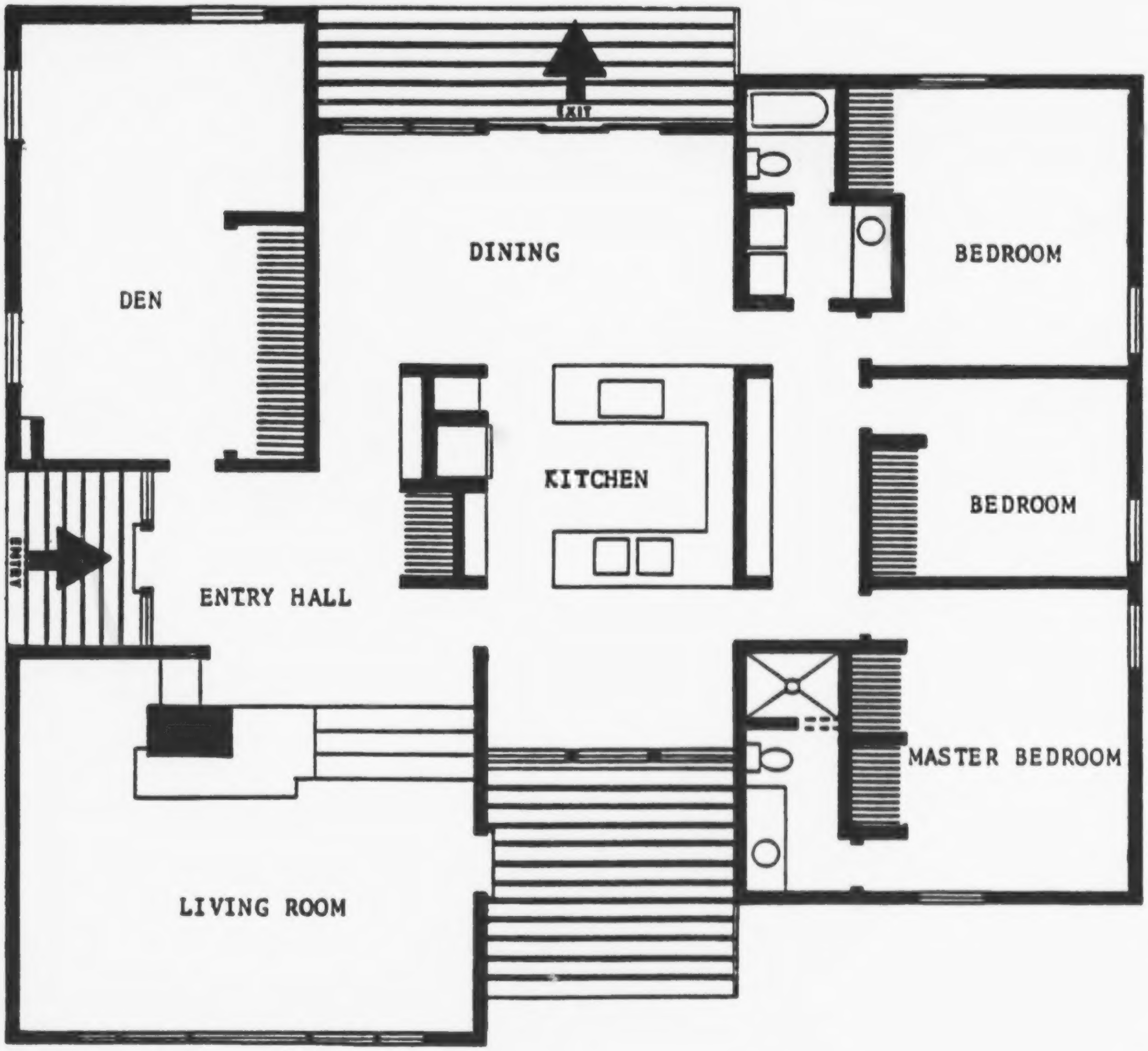
Date ______________________

Period ______________________

Work Sheet

Activity

Design a security alarm system for the house shown in the plan below. Include a control unit, various types of detectors, and one or more signal devices. Be imaginative and design a burglarproof system. Sketch in and label the individual parts of the security network. Use single lines to represent the interconnecting wires needed to "tie" the various parts together. An alarm supply company catalog or electronics supply house catalog can be used to locate information on alarm products.


EXIT
DINING
BEDROOM
DEN
KITCHEN
BEDROOM
ENTRY
ENTRY HALL
MASTER BEDROOM
LIVING ROOM

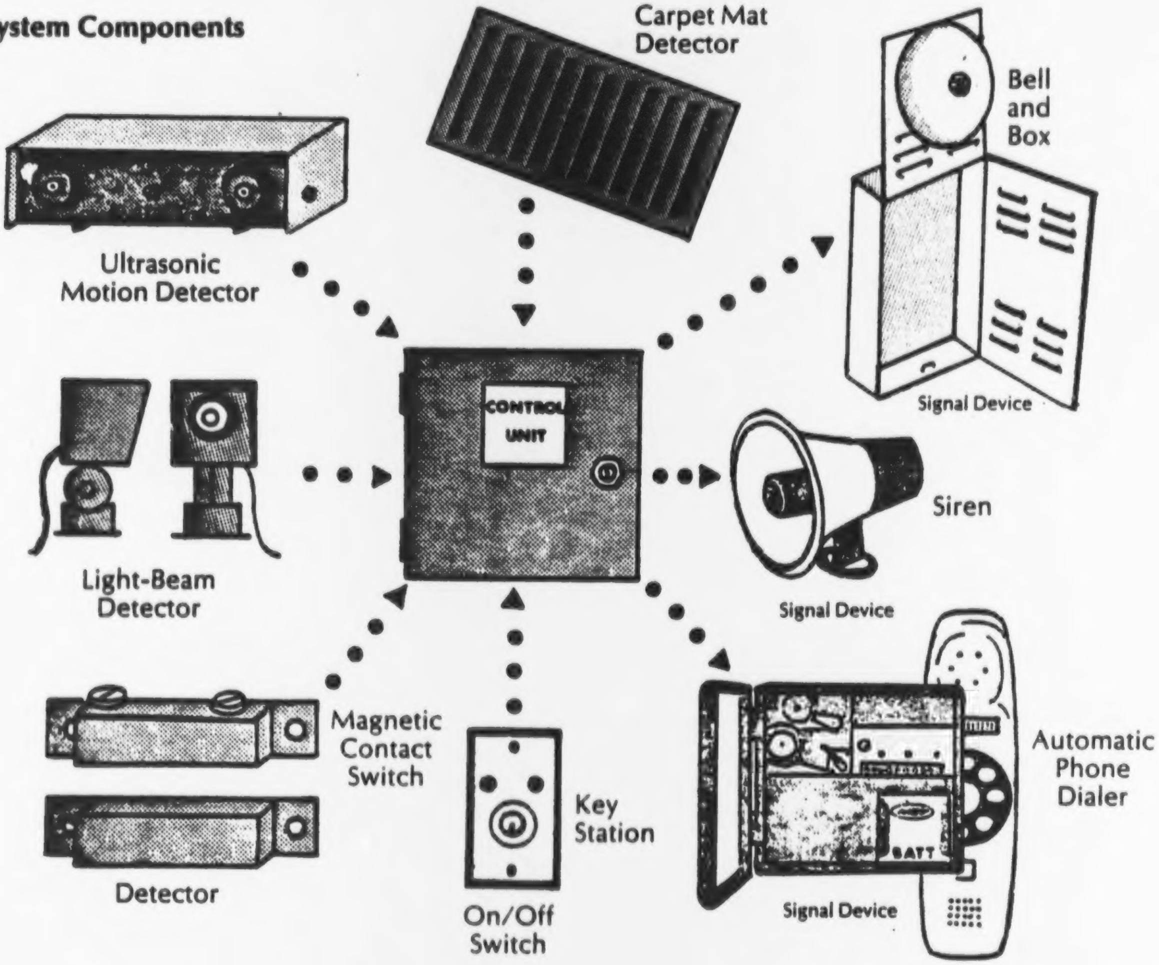
263

Informational Handout

Home Security Systems

All burglar alarm systems have three functions: detection, control, and signaling. The total system may be built into one box, or it may be made up of many separate pieces connected together with wire. Detectors are used to sense entry or movement within a protected area and are basically switches or relays which operate by movement, pressure, or beam interruption. The control unit monitors the various detectors in the system and triggers an alarm or signal device if the protection circuit sensor is interrupted or violated. The control unit also may contain on/off power switches, test meters or status indicators, time delays, power supplies, stand-by batteries, and terminals or lugs for wiring the system together. Finally, the signal device, usually a noise-making bell or siren, is used to alert or notify the owner, a neighbor, or the police that a break-in has occurred.

System Components


Carpet Mat Detector
Bell and Box
Signal Device
Ultrasonic Motion Detector
CONTROL UNIT
Light-Beam Detector
Siren
Signal Device
Magnetic Contact Switch
Detector
Key Station
On/Off Switch
Automatic Phone Dialer
BATT
Signal Device

Answer Key for Unit 18

Examination

1. L
2. D
3. C
4. E
5. M
6. N
7. A
8. B
9. F
10. J
11. (Answers will vary.)
12. (Answers will vary.)

Spelling Puzzle

1. Control
2. Circuit
3. Beam
4. Alarm
5. Signal
6. Switch
7. Device
8. Detector
9. Conductor
10. Series
11. Parallel
12. Transformer
13. Light
14. Combination
15. Ultrasonic

Series, Parallel, and Combination Circuit Wiring of Signal Devices

1. (Answers will vary.)
2. Series
3. (Answers will vary.)
4. Parallel
5. (Answers will vary.)

Activity

(Answers will vary.)

Unit 19

Circuit Protection Devices

Title of Unit: Circuit Protection Devices

Time Allocated: One week

Unit Goal

To acquaint students with the characteristics of circuit protection devices used to ensure that a circuit operates only within its designed limits

Unit Objectives

The student will be able to do the following:

1. Describe the major need for protection devices in circuits and/or equipment and identify two typical types of protection devices.
2. Demonstrate the proper technique for wiring protection devices into an electrical circuit.
3. Troubleshoot a simple electrical circuit to identify the problem which may have caused a protection device to disable the circuit or equipment that is being investigated.

Evaluation

The student will demonstrate competence in the unit objectives on the basis of performance criteria established by the individual instructors. The criteria may include a combination of written, oral, and laboratory testing procedures.

Instructor's References

Miller, Rex. *Industrial Electricity* (Revised edition). Peoria, Ill.: Chas. A. Bennett Co., 1982.

Palmore, Phyllis, and Nevin Andre. *Small Appliance Repair.* New York: McGraw-Hill Book Co., 1980.

Overview

This unit deals specifically with the needs and means for protecting electrical circuits. The topic is of tremendous importance.

The unit should be introduced with an examination of a variety of circuit failure conditions or problems, including overload. A brief discussion should be held on safety, causes of circuit failure, and methods for protecting a circuit.

Next, present an overview of the operation of several common circuit protection devices, with emphasis on the techniques for wiring them into an electrical circuit.

Finally, share with students some procedures that can be used to troubleshoot a disabled circuit. Include a demonstration of several maintenance steps that may help prevent the occurrence of an abnormal condition.

Suggested Presentation Hints/Methodology

Use this unit as a basic guideline for presenting the curriculum; however, note the following:

1. In a discussion of types (fast- or slow-blow) or kinds (plug, cartridge, knife-blade, and so on) of specific circuit protection devices, it is advantageous either to pass samples around or to use an opaque/overhead projector to help familiarize students with the physical appearances of the devices. Inform the students of the relationship between the physical size of a device and its electrical rating.
2. The topic of circuit breakers can be approached by first explaining that there are three basic types: thermal breakers, electromagnetic breakers, and thermal-electromagnetic breakers. Define all three and emphasize to the students that they are used for feeder and branch-circuit protection in home electrical systems. Advise them that the ampere rating (size) of a breaker, which is always marked on the breaker's lever, corresponds to the current-carrying capacity of the wire being protected.
3. Students should be reminded that it is extremely dangerous to tamper with a protective device. Give examples of what can happen if a fuse is intentionally bypassed or if a fuse of too large a value is used in a system.
4. An optional instructional topic on ground-fault circuit interruptors may be presented in this unit if the instructor thinks it is appropriate.

Supplemental Activities and Demonstrations

The following supplemental activities and demonstrations are suggested for use in presenting the curriculum:

1. Point out the function of the *National Electrical Code* and Underwriters' Laboratories (UL). Demonstrate where the UL label can be located. Discuss the relationship of this label to safety.
2. Obtain an old Edison-base fuse and show it to the class. Explain that this type of fuse is no longer allowed in home construction because it is considered to be tamperable. Elicit from the students whether they think this fuse is too dangerous to be used in new homes. If they feel it is, have them tell why.
3. Demonstrate the technique for checking the continuity of a fuse. Refer to the device's resistance as a means to evaluate its quality.

Instructional Unit Contents

1. Unit Outline (overhead)
2. Pretest and Post-test (keyed)
3. Technical Glossary
4. Work Sheet (vocabulary)—Know Your Definitions
5. Activity
6. Informational Handout (Circuit Protection Devices)
7. Answer Key for Unit 19

Unit 19

Circuit Protection Devices

(Lecture Outline)

A. Why Circuits and Equipment Require Protective Devices
   1. Runaway current
   2. Circuit failure

B. Types and Operation of Protective Devices
   1. Fuses
   2. Circuit breakers

C. Wiring of Protective Devices into an Electrical Circuit

D. Troubleshooting Circuits for Causes of Protective Device Failure

E. Maintenance Information on Fuses and Circuit Breakers

Test number ________

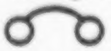
Examination for Unit 19

Circuit Protection Devices

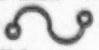
Write your answers to the questions on the answer sheet. Fill in the box that corresponds to the correct answer to the question. Each question has only one correct answer.

1. A fuse or circuit breaker must be connected in series with the circuit it is protecting. (T-F)
2. When a fuse link melts or blows, the electrical result is an open circuit. (T-F)
3. Miniature cartridge fuses are often used in automotive and instrument circuits. (T-F)
4. An overload can be safely prevented by increasing the size of the fuse that is protecting the circuit. (T-F)
5. Circuit breakers are used mainly on instruments and appliances. (T-F)
6. A short circuit causes an extremely high current to flow through the circuit. (T-F)
7. Circuit protection devices are rated according to the maximum current or amperage which can flow through them. (T-F)
8. Circuit breakers require occasional maintenance, which involves manually tripping the device on and off. (T-F)
9. Circuit breakers contain several replacement fuse links that can be switched into position by moving a lever. (T-F)
10. A 15-ampere fuse can be used in a home outlet or lighting circuit. (T-F)
11. If the correct size fuse in a circuit continually blows or burns out, a bad fuse or the need for a larger value fuse is indicated. (T-F)
12. When the current flowing through a circuit breaker is below the device's rated value, the breaker will trip. (T-F)
13. A circuit overload can be caused by:
    1. A fuse with a low amperage rating
    2. Too many loads on the circuit
    3. An accidental low-resistance path
    4. Either 2 or 3
14. A prolonged overload current:
    1. Can be avoided by using a fuse of higher amperage rating
    2. Will not affect the circuit's operation
    3. May melt insulation and cause a short or fire
    4. Usually will not trip a circuit breaker
15. A short circuit:
    1. Is an extremely low-resistance path which causes higher than normal current flow
    2. Cannot occur in a circuit protected by the proper size fuse or circuit breaker
    3. Can occur only in an alternating current circuit
    4. Seldom causes the fuse or circuit breaker to open

Technical Glossary

Circuit breaker—A circuit protection device which is basically a thermal or electromagnetic switch designed to break the current flow through a circuit in case of an overload or short. Circuit breakers are rated in amperes and have an advantage over fuses in that they can be easily reset many times. The symbol for circuit breakers is .

Circuit protection device—A device used to protect a circuit from the potentially destructive effects of excessive current. The most common circuit protection devices are fuses and circuit breakers.

Fuse—A device used to protect a circuit against excessive current flow. Fuses are rated in amperes and contain a calibrated "fuse link" which burns or vaporizes when too much current begins to flow through it. The symbol is .

Fuse link—The thin strip of fusible metal that is built into a fuse and that melts when the current flow through it exceeds a designated value. The higher the blow-out current rating, the larger the physical size of the fuse link. These links can take the form of hair-thin wire or fairly thick strips of metal and can be calibrated to hundredths of an ampere.

Overload—An unsafe circuit condition which occurs when a circuit carries more current than it can safely handle. Overloads can cause excessive heat, fire, or an electrical explosion.

Runaway current—A circuit condition, such as a short, which allows the current in a circuit to increase uncontrollably past the safe limit of the circuit.

Short circuit—An accidental circuit condition which results in a low-resistance path between two points of the circuit (power supply terminals, line, and so on). A shorted circuit causes excessively high current flow and possible circuit damage.

Troubleshooting—The process of logically locating and correcting improper operating conditions within an electrical circuit or system.

Score ________

Grade________

Name ______________________

Date ______________________

Period ______________________

Work Sheet

Know Your Definitions

Write in your own words short definitions for the following terms:

1. Fuse
2. Overload
3. Short circuit
4. Troubleshooting
5. Circuit breaker
6. Fuse link

Score ____________

Grade____________

Name ______________________________

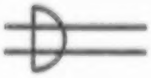
Date ______________________________

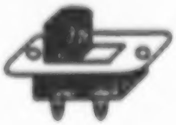
Period ______________________________

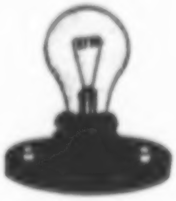
Work Sheet

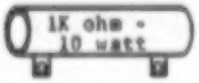
Activity

1. Draw in the conductors and connect the circuit components below to form a series circuit. Add a fuse to protect the circuit against an overload or short.

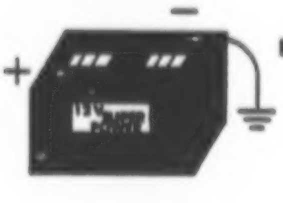




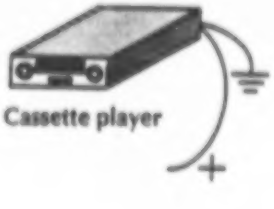




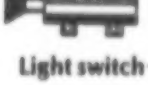
2. Connect the following automotive devices in parallel with the source and in series with their controls. Add an in-line fuse to the tape deck branch and a circuit breaker to the headlight branch.



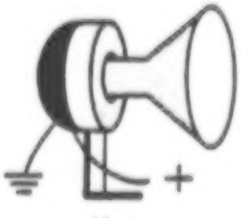
Battery



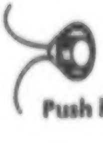
Cassette player



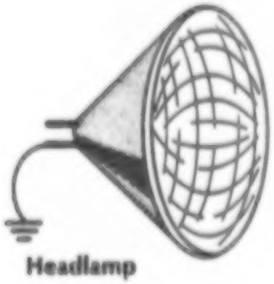
Light switch



Horn



Push button



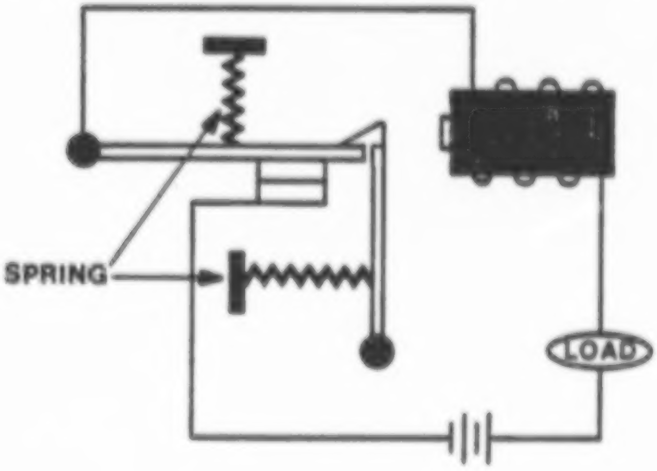
Headlamp

3. Draw a fast acting (fast-blow) fuse and a slow acting (slow-blow) fuse.

Fast acting **Slow acting**

4. Explain the purpose of or need for a slow acting fuse.

5. Explain how the circuit breaker pictured below operates.

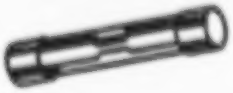


Informational Handout

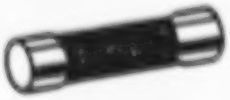
Circuit Protection Devices

Fuses or circuit breakers make up the major types of circuit protection devices in use today. These devices are used to protect against excessive current flow in a circuit and are rated in amperes. Fuses react to an abnormally high current by melting or vaporizing a special metal link which opens the circuit and halts the current flow. Circuit breakers contain either an electromagnet or a bimetallic thermal strip, which opens a set of switch contacts when the breaker's rating is exceeded. Once the contacts open, the circuit current is stopped.

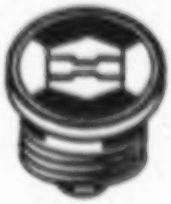
Types of Fuses



Miniature cartridge fuse

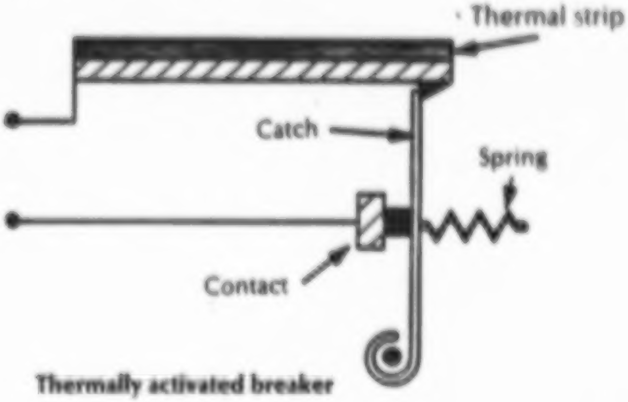


Cartridge fuse

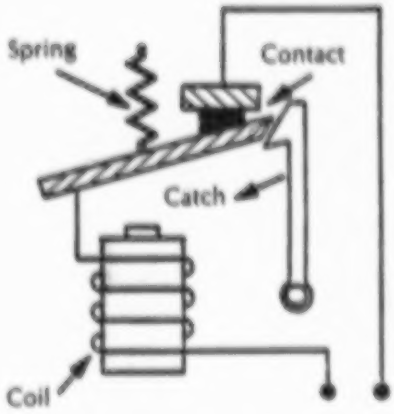


Plug fuse

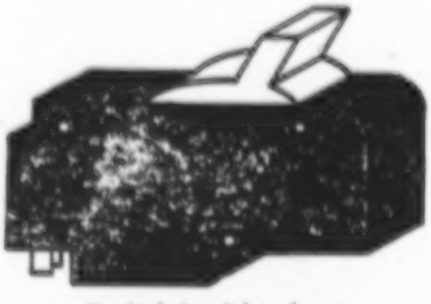
Types of Circuit Breakers



Thermally activated breaker



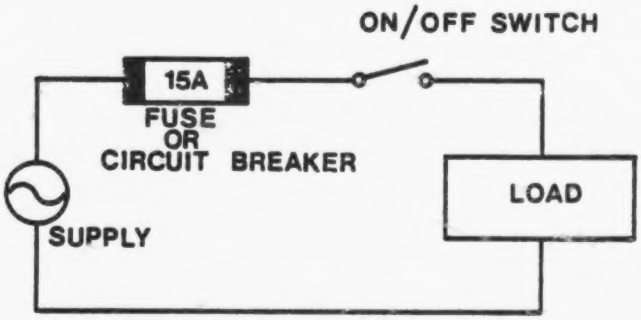
Electromagnetic breaker



Typical circuit breaker

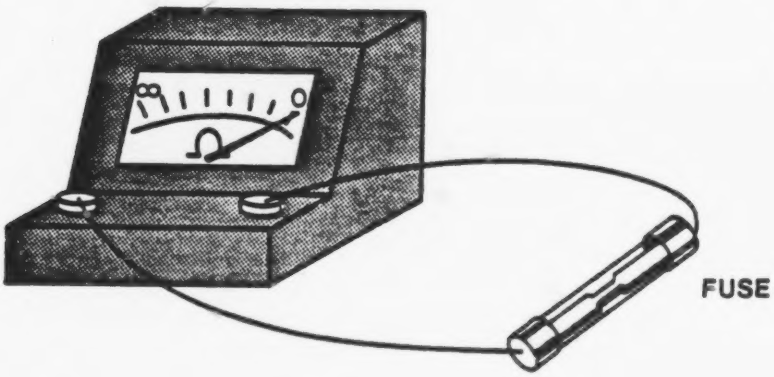
Circuit Connection

To protect a circuit from excessively high current flow, fuses and circuit breakers must be connected in series with the circuit they are protecting. A typical circuit application is shown below.


ON/OFF SWITCH
15A
FUSE
OR
CIRCUIT BREAKER
LOAD
SUPPLY

Fuse Testing with an Ohmmeter

Many times a quick visual inspection of a fuse's condition can be misleading. A fuse may look good when it is actually burnt out or defective. A sure way to check a fuse is to conduct a simple continuity test, as illustrated below.



Answer Key
for Unit 19

	T	F		
	1	2	3	4
1.	■			
2.	■			
3.	■			
4.		■		
5.		■		
6.	■			
7.	■			
8.	■			
9.		■		
10.	■			
11.		■		
12.		■		
13.				■
14.			■	
15.	■			
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
25.				

Know Your Definitions

1. (Answers will vary.)
2. (Answers will vary.)
3. (Answers will vary.)
4. (Answers will vary.)
5. (Answers will vary.)
6. (Answers will vary.)

Activity

(Answers will vary.)

Unit 20

House Wiring

Title of Unit: House Wiring

Time Allocated: Two weeks

Unit Goal

To improve students' competence in evaluating the method used to deliver power to the home and to help students become familiar with residential wiring materials and basic household circuitry

Unit Objectives

The students will be able to do the following:

1. State the specific function of a service connection and describe in detail what is being measured by a kilowatt-hour meter.
2. Identify and differentiate between a variety of basic electrical wiring components and materials, including a duplex receptacle, switch, conduit, and sheathed cable, which may be encountered in home electrical circuits.
3. Demonstrate simple wiring skills and recite the procedures that are necessary to replace a fuse, reset a circuit breaker, and/or replace an electrical switch or outlet.

Evaluation

The student will demonstrate his or her competence in the unit objectives on the basis of performance criteria established by the individual instructors. The criteria may include a combination of written, oral, and laboratory testing procedures.

Instructor's References

Miller, Rex. *Industrial Electricity* (Revised edition). Peoria, Ill.: Chas. A. Bennett Co., 1982.

Mix, Floyd M. *Housewiring Simplified.* South Holland, Ill.: Goodheart-Willcox Co., 1981.

Steinberg, W. F., and W. B. Ford. *Electricity and Electronics* (Fourth edition). Chicago: American Technical Society, 1982.

Overview

Unit 20 should begin with a review of the basic concepts presented in units 17 and 18.

The main purpose of the unit is to inform the students about basic house wiring. However, it is not recommended that they attempt to install wiring in a home. It is conceivable that they may acquire enough fundamental competencies to allow them to replace a switch or outlet.

At the outset of the unit, explain the purpose of the service connection and the method of reading a kilowatt-hour meter.

Next, describe typical electrical materials that are associated with electrical construction wiring. Emphasize also various kinds of household circuits and some simple repair and installation procedures.

Suggested Presentation Hints/Methodology

Use this unit as a basic guideline for presenting the curriculum; however, note the following:

1. This unit is more effective if the students have an opportunity to manipulate the actual materials and wiring apparatus. If a commercially produced wiring demonstrator is not available, it is fairly easy to create a usable instructional device to facilitate this unit of instruction. Work with the woodworking and drafting instructors and design a portable wall demonstrator that can be rotated into the different laboratories as needed to illustrate various principles in house construction, architectural design, and/or residential wiring. The wall demonstrator should be able to accommodate several pairs of students, and it should realistically simulate a wall and partial ceiling section. Additional electrical parts and materials, such as switches, lights, a kilowatt-hour meter, nonmetallic sheathed cable, signalling devices, and fixtures, may be mounted as desired to accommodate wiring experiments.
2. An interesting and economical instructional device which can be used to help students comprehend electrical wiring techniques is simple to develop. Cut an assortment of 2-foot by 2-foot (61 centimetre by 61 centimetre) pieces of particle board and cover each with butcher paper. Draw with a marker a diagram of a common residential wiring circuit. Have the students

mount appropriate parts right over the diagram and wire the parts. Inspect, test, and grade their progress.

Supplemental Activities and Demonstrations

The following supplemental activities and demonstrations are suggested for use in presenting the curriculum:

1. Add a new dimension to a wall demonstrator activity by having available in the shop four or five laboratory coats of various sizes. A logo such as "Joe's Electrical Repair" can be affixed to the coats. If possible, issue standard electricians'-type tool holders, which can be strapped to the waist and filled with an assortment of tools and materials. This role-playing atmosphere will generally stimulate students' interest in the activity.
2. Contact a local electrical company and ask whether it would be possible to take slides of a crew working at a jobsite. Show these slides to the class and discuss the kinds of activities electricians perform and the qualifications and training which are typically required for electricians.

Instructional Unit Contents

1. Unit Outline (overhead)
2. Pretest and Post-test (keyed)
3. Technical Glossary
4. Work Sheet (vocabulary)—Word Search
5. Activity
6. Informational Handout (Electric Service Drop)
7. Informational Handout (Helpful Hints About Basic Electrical Installation and Repair)
8. Answer Key for Unit 20

Unit 20

House Wiring

(Lecture Outline)

A. Service Connection

B. The Kilowatt-Hour Meter
   1. Electrical energy measurement
   2. Meter reading and energy cost
   3. Comparison of power used by different household appliances
   4. Methods of conserving energy
   5. Relationship between human comfort and energy consumption

C. Wiring Materials

D. House Fixture Wiring
   1. Switching circuits
   2. Outlet circuits

E. House Wiring Requirements

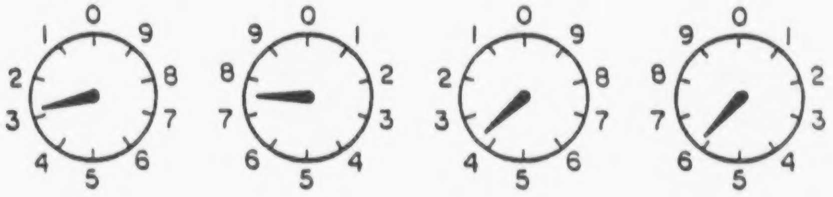
Test number ________

Examination for Unit 20

House Wiring

Write your answers to the questions on the answer sheet. Fill in the box that corresponds to the correct answer to the question. Each question has only one correct answer.

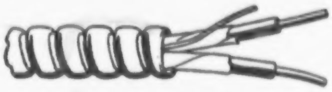
1. The amount of electrical energy consumed in your home is measured by a kilohour-watt meter. (T-F)
2. The individual dials of a kilowatt-hour meter all have the same kilowatt-hour value. (T-F)
3. The basic energy unit used by electric companies to compute their customers' bills is the watt-hour. (T-F)
4. The kilowatt-hour meter is connected between the entrance head and the distribution panel in such a way that all energy consumed can be accurately measured. (T-F)
5. A branch circuit and a series circuit are the same. (T-F)
6. The bare copper wire found in home wiring systems is always a "hot" wire. (T-F)
7. Normal home electrical service is designed to supply both 120 volts and 240 volts. (T-F)
8. The advantage of a fuse is that it can be easily reset by moving a lever. (T-F)
9. The standard color coding for the neutral wire used in home wiring is white. (T-F)
10. In the installation of a duplex outlet, the brass attachment screw is connected to the hot, or black, wire. (T-F)
11. A circuit overload will generally not cause a circuit breaker to trip. (T-F)
12. If you work carefully, it is perfectly safe to replace a wall switch or duplex outlet without turning off the main power. (T-F)
13. Each branch circuit in the home should contain either a fuse or a circuit breaker to prevent short circuit conditions. (T-F)
14. Overloaded glass cartridge fuses can be identified by an open or burned fuse link. (T-F)
15. What is the reading on the kilowatt-hour meter shown below?



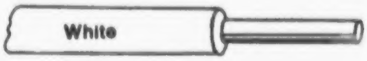
1. 6,372   2. 2,736   3. 3,746   4. 2,746

Identify the following residential wiring items by matching the sketches with item descriptions. Record on your answer sheet only the letter of the identifying term.

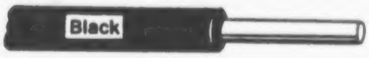
16.



17.



18.



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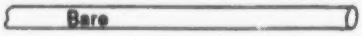
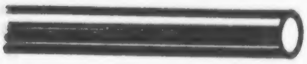


20.



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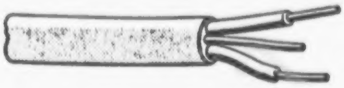

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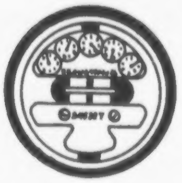

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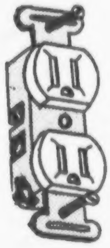
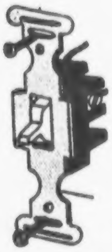


24.



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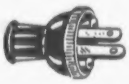

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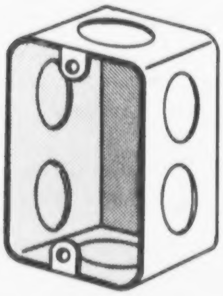
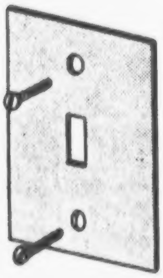
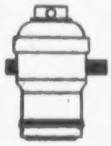


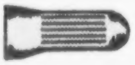
27.



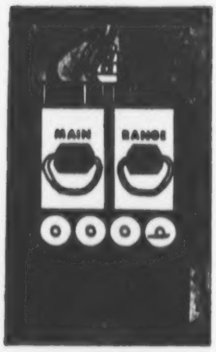
28.



29.



30.



A. Hot wire
B. Cover plate
C. Wall switch
D. Armored cable
E. Lamp socket
F. Crimp connector
G. Distribution panel
H. Conduit
I. Neutral wire
J. Twist connector (wire nut)
K. AC plug
L. Receptacle (110V)
M. Entrance head
N. Box
O. Nonmetallic sheathed cable
P. Ground wire
Q. Kilowatt-hour meter
R. Fixture box

Technical Glossary

Alternating current (AC) plug—A two- or three-prong plug attached to one end of a line cord. The alternating current plug mates with the wall outlet or receptacle to provide a contact with the 120V source.

Appliance circuit—A home wiring circuit, generally found in the kitchen and laundry areas, which is designed to supply the power required to operate large appliances, such as a dishwasher, refrigerator, microwave oven, and washing machine. The circuit is typically designed for a 20-ampere current flow and requires at least 12-gauge wire.

Armored cable—A semiflexible, metallic sheathed cable used for interior wiring. Armored cable is generally used when wiring 220V circuits, such as electric range and clothes dryer circuits.

Boxes—A steel or nonmetallic box attached to a stud or inner wall and used to house switches, outlets, and lighting fixtures and their connecting wires.

Branch circuit—A parallel circuit which supplies current to various load devices from a single voltage source. Outlet circuits are generally connected as branch circuits, and each branch is protected by a fuse or circuit breaker.

Color coding (wire)—A conductor identification system designed to code wire function by means of various colors. Typically, wires of different colors are not connected together. For residential application, white is used to indicate neutral, black is used to denote the hot wire, and green is used to represent earth ground.

Conduit—Thin-walled metal tubing, usually ¾ inch (1.9 centimetres) or 1 inch (2.3 centimetres) in diameter, used to house electrical conductors or wires.

Conservation—The process of saving or limiting the use of a resource, such as electrical energy.

Distribution panel—A panel or box, usually found directly below the kilowatt-hour meter, which contains the main switch used to turn off the electricity to the home and the various fuses or circuit breakers used to protect the various circuits. All wiring for each branch circuit begins at the distribution panel.

Electric service panel—The main panel or cabinet through which electric power is brought into the home and distributed to the various branch circuits. The service panel generally contains the kilowatt-hour meter, the main power disconnect, and the circuit breakers or fuses for each branch circuit.

General purpose circuit—A house wiring circuit used for lighting fixtures and outlets in all rooms, except the kitchen and laundry area. One general purpose branch is used for each 500 square feet (46.5 square metres) of floor space and is generally protected by a 20-ampere 120V fuse.

Grounded—Describing a wire or conductor which is electrically connected to the earth.

Grounding wire—An additional wire used in an electrical circuit as a safeguard against electrical shock. In home and appliance circuits, this wire is color coded green. During normal circuit operation, the grounding wire is not in use, but in an abnormal situation, such as a live wire accidentally coming in contact with the frame, the grounding wire provides a safe path for electron flow.

Hot wire—Any wire that carries electrical current. In the home these wires can be any color except white and green; they are usually black, blue, or red.

Individual circuit—A branch circuit in the home designed to serve individual pieces of electrical equipment, such as ranges, water heaters, and air conditioners. Each circuit is protected by a fuse or circuit breaker.

Kilowatt-hour—The electrical unit of measure for the amount of power/energy consumed in the home. The abbreviation for kilowatt-hour is KWH.

Kilowatt-hour meter—A meter used to monitor and record the amount of electrical energy consumed in the home. The kilowatt-hour meter is connected in series with the service drop and is read monthly by the electric utility company. These monthly readings form the basis for computing electricity bills.

Lamp socket—A screw-type socket used to hold an electric light bulb. The socket provides an electrical contact for the contact points in the light bulb and may also contain an on-off switch.

Line cord—A group of two or three stranded flexible conductors used to connect lamps and appliances to outlets. Line cords can be grouped into three basic types: lamp or fixture cords, appliance or heater cords, and service or power cords. The main differences between the types is in the gauge of the stranded conductors and the kind of insulation used.

National Electrical Code—A set of rules written by the National Fire Protection Association and the American National Standards Institute. The purpose of these rules is to safeguard persons, buildings, and contents from hazards arising from the use of electricity. Following the standards set down by the *National Electrical Code* will result in buildings that are essentially free from electrical hazard.

Neutral wire—The white wire or conductor used in home wiring; also known as the ground return wire. This wire must be grounded at the main switch or fuse panel and run to each outlet without being broken or interrupted.

Nonmetallic sheathed cable—An assembly of two or more insulated wires with an outer sheath or covering of a moisture-resistant, nonmetallic material.

Receptacle—A contact device, sometimes called a wall outlet, which provides a point to plug in 120V devices such as lamps, stereos, television sets, and small appliances.

Service drop—The conductors which extend from the street's main lines or the pole transformer to the home. A typical home service consists of three wires: two 115V lines and one neutral wire.

Solderless connector—Also known as a wire nut or twist connector. These devices are used to connect two or more wires in a semipermanent or permanent manner. Basically, these devices are tapered, internally threaded plastic insulators which twist on to the bare ends of the conductors to hold them together firmly.

Three-way switch—A type of wall switch which requires three connections rather than the normal two. A pair of three-way switches can be used to control a light from two different locations.

Wall switch—A tumbler switch. A device used to open and close the current path of a circuit. Wall switches are typically used in the home to turn lighting circuits on and off. Switches are used only on hot wires (black, blue, or red) and never on neutral or ground wires.

Wire gauge—A numerical system for sizing wires; commonly called AWG (American Wire Gauge) number. The larger the wire number, the smaller the diameter of the wire. Common AWG sizes for home wiring are 10, 12, and 14 gauge.

Score ____________

Grade____________

Name ______________________________

Date ______________________________

Period ______________________________

Work Sheet

Word Search

Locate the electrical terms in the puzzle below and then record them in the spaces provided. The first letter is given for each term. In ten instances, two words form the term; in one instance, three words form the term. Circle the words as you find them. Words may be spelled forward, backward, vertically, horizontally, or diagonally, but they must be in a straight line.

```
A G C Z F T I J J G L A M P S O C K E T S O P T F
H I O L M J D I S T R I B U T I O N D O U A A H U
S J N A K Q L I N E C O R D N O P C R R Q R O R N
X M D E R H U P D Q N E U P K M K O S U M R T E Y
R G U G U O Z A C P L U G N T M N N C O B V J E F
M O I N E T Z B E A A I Y I D R O S R H K L O W B
H E T L H W R E C E P T I C L E K E L T T I P A L
P E C V C I S A E T M N V T R S D R T T J O A Y H
B O X E S R A S L U L O L F N C T V K A X E N S I
L R M D B E U L K W Y C S O A L Y A G W W I E W L
N I S E G U A G E R I W O B N D E T P O Z I M I P
E L E C T R I C L B C R L U A N J I C L A B A T A
D I C B T U K Q E K J E E V E V O O H I M W L C E
H C T I W S L L A W Y R S Z P L J N X K E W S H D
T H M S E R V I C E D R O P Z A P E L Q R E W X E
```

1. C ______________________________

2. C ______________________________

3. G ______________________________

4. L ______________________________

5. L ______________________________

6. A ______________________________

7. A ______________________________

8. B ______________________________

9. K ______________________________

10. N ______________________________

11. R ______________________________

12. S ______________________________

13. T ______________________________

14. W ______________________________

15. W ______________________________

16. H ______________________________

17. D ______________________________

18. E ______________________________

Score ________

Grade________

Name ________________________________

Date ________________________________

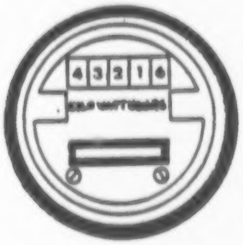
Period ________________________________

Work Sheet

Activity

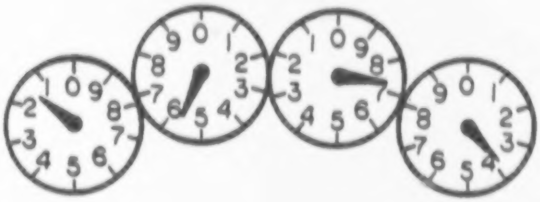
Read the values indicated on the kilowatt-hour meters pictured below and record them in the spaces at the right.

1.


43216
KILOWATTHOURS

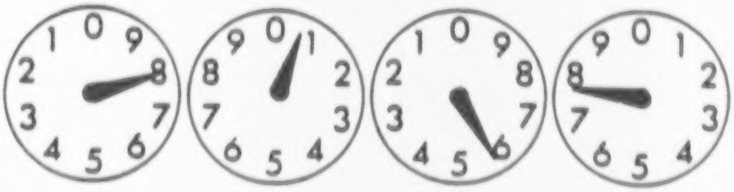
1. ____________________

2.



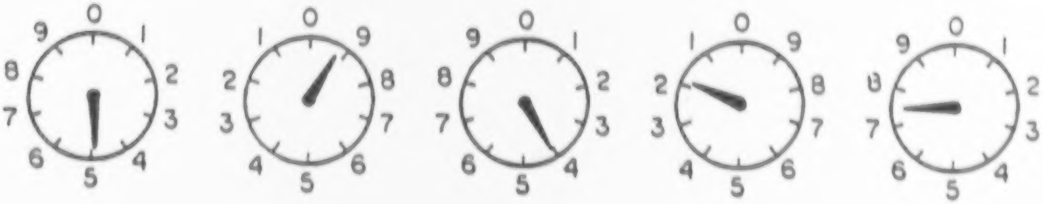
2. ____________________

3.



3. ____________________

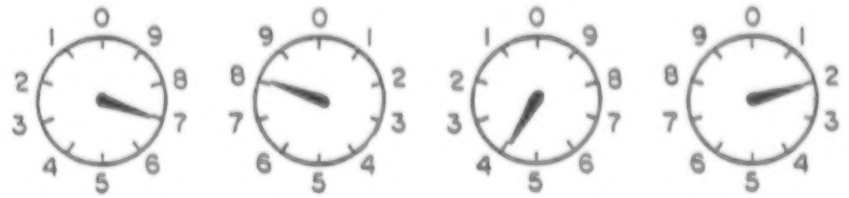
4.



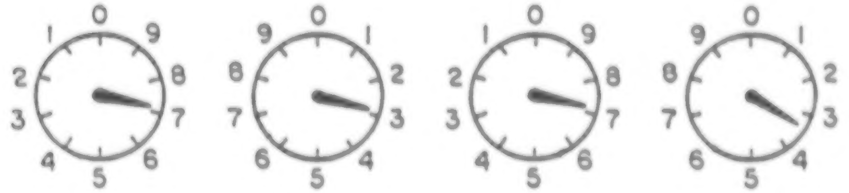
4. ____________________

5A. Determine the number of kilowatt-hours of electricity consumed by this consumer by using the meter scales below.

5A. ____________________



Reading taken on Dec. 31



Reading taken on Jan. 31

Show work.

5B. Compute the cost of this electrical energy if each kilowatt-hour is billed at a rate of $0.021 with an additional basic service charge of $1.60.

5B. ____________________

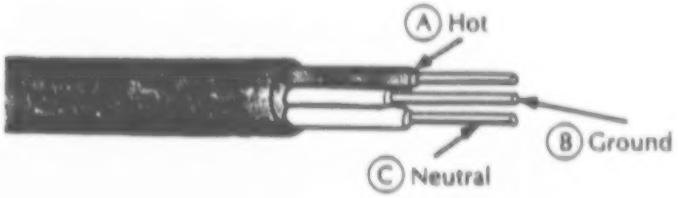
Show work.

6. Give the NEC standard color code for the home wires depicted below.

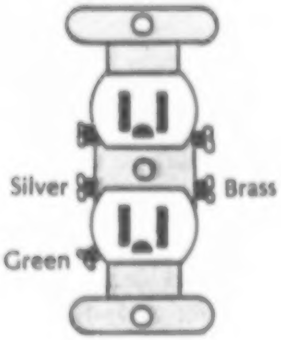
6A. ____________________

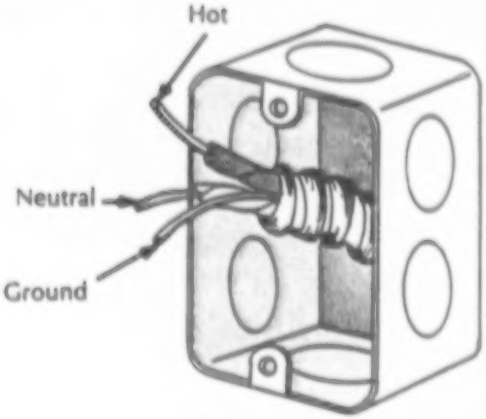
6B. ____________________

6C. ____________________

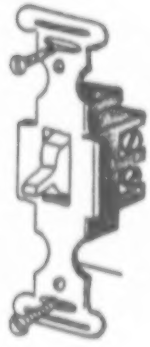


7. Route and correctly connect the wires coming from the armored cable to the duplex outlet.

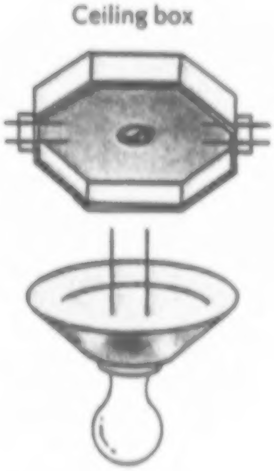

Silver
Brass
Green


Hot
Neutral
Ground

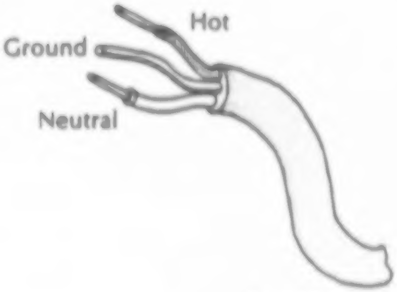
8. Wire the wall switch circuit below in such a way that it will control the operation of the lamp.



Switch


Ceiling box

Socket


Hot
Ground
Neutral

Source

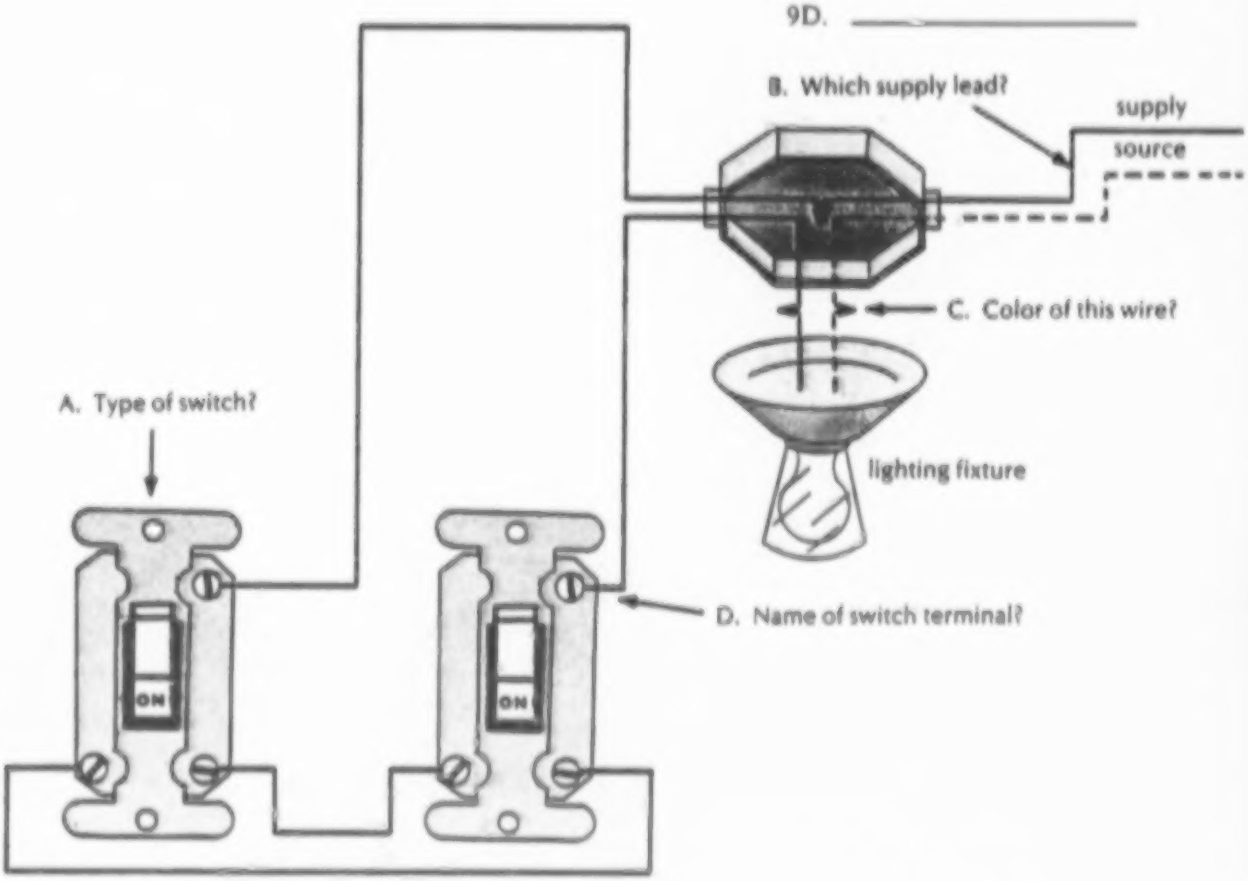
9. Identify the items indicated for in the lighting circuit below.

9A. ______________________

9B. ______________________

9C. ______________________

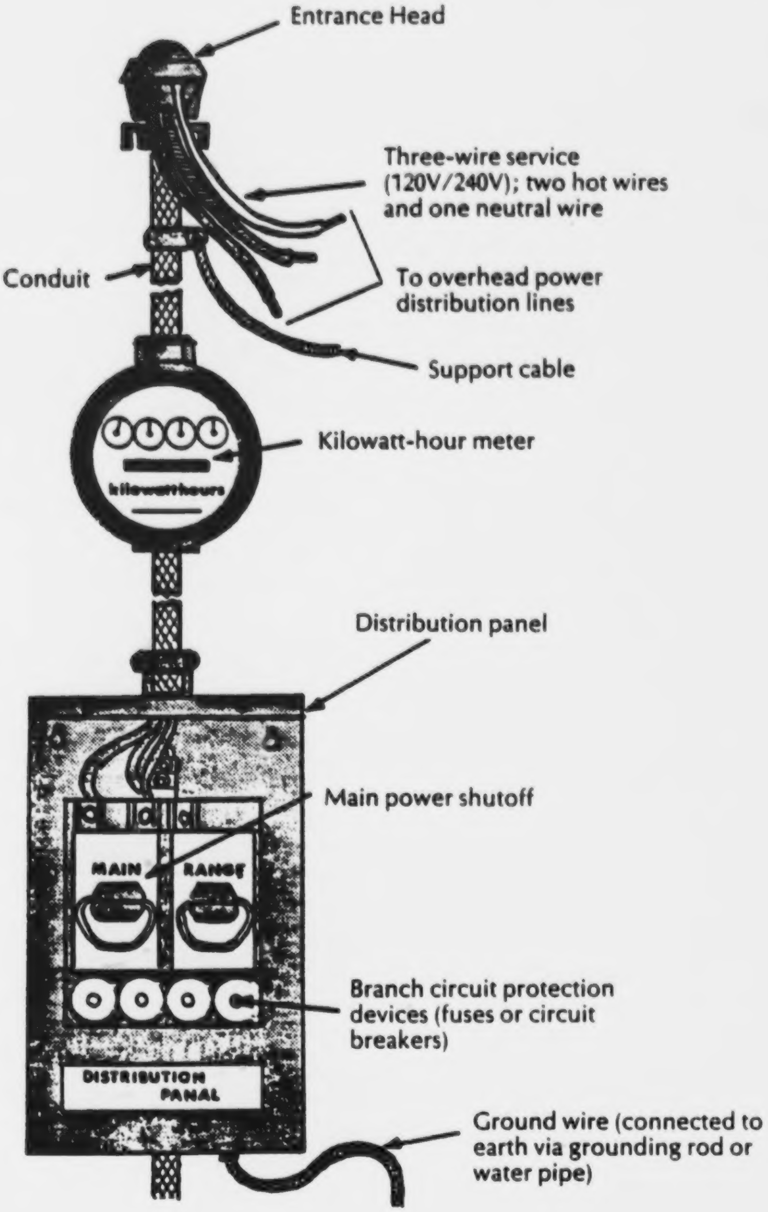
9D. ______________________


B. Which supply lead?
supply
source
C. Color of this wire?
A. Type of switch?
lighting fixture
D. Name of switch terminal?
ON
ON

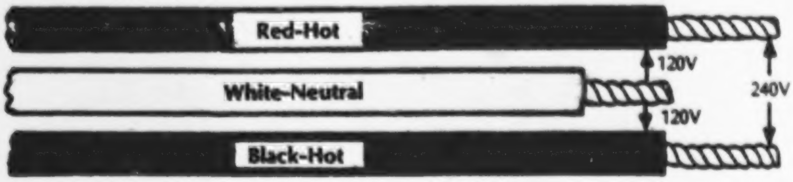
10. Explain the purpose of a three-way switch circuit.

Informational Handout

Electric Service Drop


Entrance Head
Three-wire service (120V/240V); two hot wires and one neutral wire
Conduit
To overhead power distribution lines
Support cable
Kilowatt-hour meter
kilowatthours
Distribution panel
Main power shutoff
MAIN
RANGE
Branch circuit protection devices (fuses or circuit breakers)
DISTRIBUTION PANAL
Ground wire (connected to earth via grounding rod or water pipe)

The electric service drop pictured above is typical of many power installations capable of supplying 120V/240V service to the home. Three wires, along with a support cable, extend from the overhead distribution line to the entrance head on the building. Two of the wires carry a 120V potential and are referred to as the hot wires, and the third wire is a ground, or neutral, conductor. Voltages are developed across the conductors, as shown below.



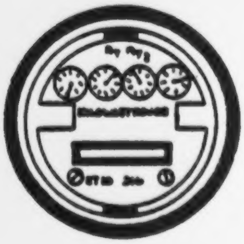
Along with the available voltages, a system must also be designed to handle a certain maximum current flow. Most single family homes are designed for either 100- or 150-ampere service.

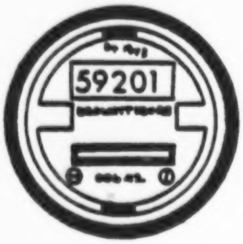
As electrical energy moves from the entrance head to the distribution panel, it flows through a kilowatt-hour meter. This meter is designed to measure the amount of electrical energy consumed in the home and is monitored by the local power company. The power company, in turn, computes the monthly electric bill, based on the number of kilowatt-hours of energy used.

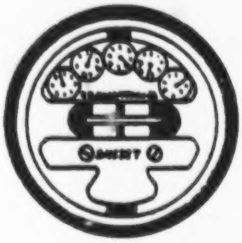
After flowing through the kilowatt-hour meter, the current is directed into the distribution panel. This panel contains the main power disconnect (a switch, fuse block, or circuit breaker which can be used to turn off all power to the home) and the various protection devices (fuses or circuit breakers) used in each branch circuit. The wires then leave the circuit panel and enter the home to form the various general purpose, appliance, and individual wiring circuits.

You may want to read your electric meter to compute your monthly electric bill or periodically check the consumption of electrical energy. Some meters have a numerical readout, which is simple to read, while other meters use a series of dials and pointers to indicate a measurement.

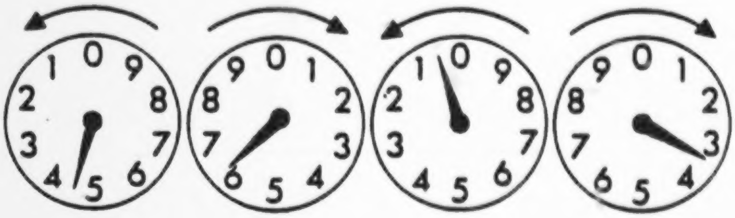
The drawing below shows several styles of kilowatt-hour meters. Locate the meter at home—it may be different from those pictured.





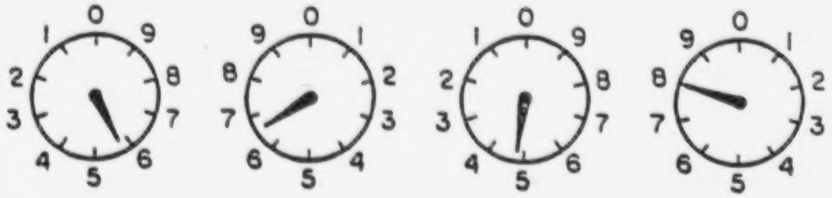


The kilowatt-hour meter is basically a current-sensitive motor that is connected to a gear-driven counter. On a dial-type counter, each adjacent pointer rotates in the opposite direction, as pictured below.



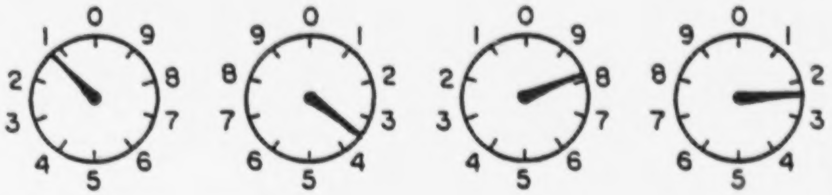
To read a meter similar to the one pictured above, start with the dial at the left and write down the last number the pointer has passed on each dial. Thus, the reading on the meter would be 4,603 kilowatt-hours.

Let's try a few more sample readings.

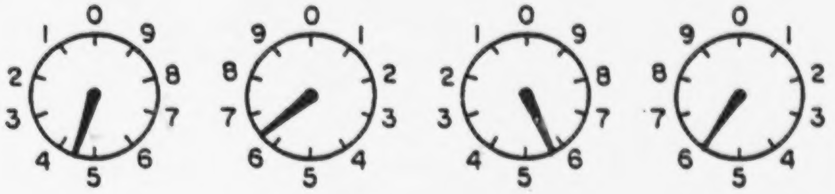


The meter pictured above indicates a reading of 5,648 kilowatt-hours. Even though the pointer falls between two numbers, always read to the lower value; also, each dial corresponds to a place value in our numbering system (ones, tens, hundreds, and so forth).

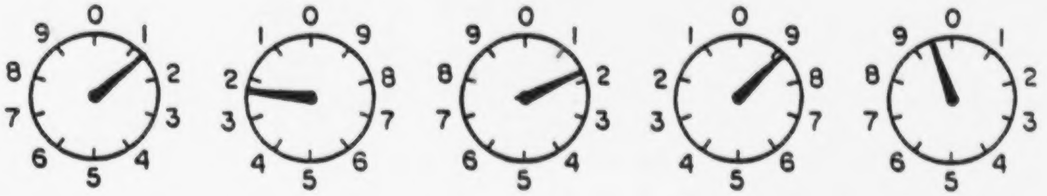
Read the meters below.



Reading ____________



Reading ____________



Reading ____________

Answers:

1. 1,382 2. 4,656 3. 12,189

Informational Handout

Helpful Hints About Basic Electrical Installation and Repair

The tips and sequence that follow should be used only as a guide for minor electrical work.

Minor Work

- Repair of blown fuses
- Resetting of circuit breakers
- Replacement of electrical switches and outlets
- Identification of an overloaded circuit

Major Work

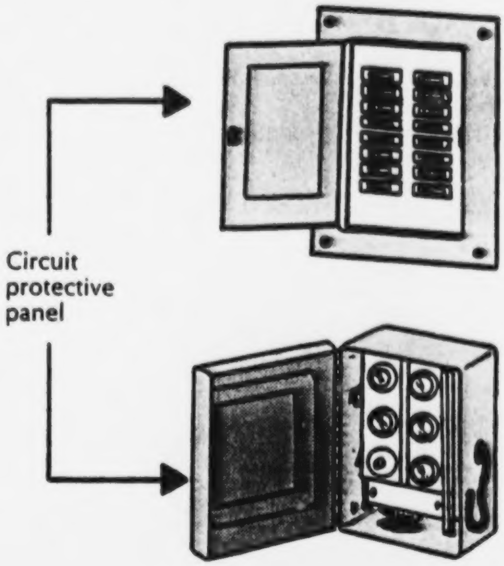
- Wiring which must conform to a standard or code and generally requires a licensed electrician to complete

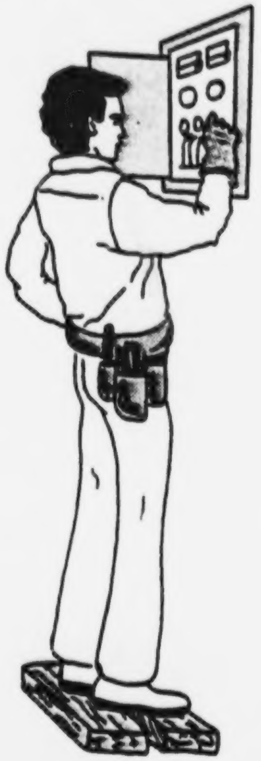
Safety

Be safe, not sorry! Never work on a circuit unless the main power or the power to the branch circuit is shut off. **Double-check.**

Never touch a circuit protective panel (fuse or circuit breaker box) unless you observe the following precautions:

- Handle panels with one hand only.
- Wear insulated gloves.
- Wear rubber soled shoes.
- Stand on a board or other insulating material.
- Know the proper procedure for each situation.





Fuses

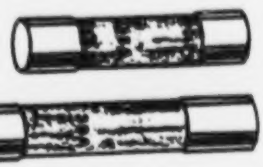
From the service connection, electrical power goes to the circuit protective panel, where it is routed into the appropriate branch circuits. The panel houses many circuit protective devices which will stop current flow when something is wrong!

Many older homes use plug and cartridge fuses, and you should know how to replace these.

Cartridge-Type Fuses

Cartridge-type fuses have the following characteristics:

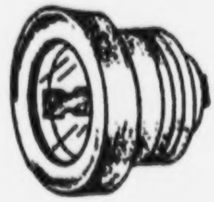
- There is no visible indication when the fuse is blown.
- Fuses are installed in pullout drawers.
- The end cap on the meter side of the fuse is always "hot."
- A wooden tool should be used to remove the old fuse.
- The main power should be off when the fuse is replaced. Look at the label on the panel, find the bad circuit, and replace that fuse.



Plug-Type Fuses

Plug-type fuses have the following characteristics:

- The window is discolored or the metal strip is broken when the fuse is blown.
- Blown fuses should be replaced only with the proper size and type of fuse.
- The main power should be off when the fuse is replaced. Look at the label on the panel, find the bad circuit, and replace the fuse.



Final Circuit Check

Before turning the power back on, unplug all appliances from the electrical circuit which was disabled. Turn the power on after the fuse has been replaced and then plug each appliance in one at a time and observe the panel and appliance. If the fuse blows again, the last appliance that was plugged in must be repaired. If all goes well, the circuit was probably *overloaded* with too many items plugged into it.

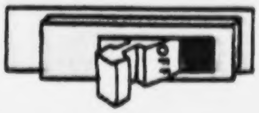
Circuit Breakers

Many new homes use circuit breakers (switch-type or push-button) to protect wiring in the home.

Switch-Type Circuit Breakers

Be aware of the following about switch-type circuit breakers:

- They are located in a panel enclosure.
- The circuit can be opened automatically or manually.
- When a breaker is tripped, the switch label will read OFF.
- A circuit breaker is reset by flipping the switch to the ON position.



Push-button-Type Circuit Breakers

Be aware of the following about push-button circuit breakers:

- They are located in a panel enclosure.
- A circuit can be opened automatically or manually.
- When a circuit is tripped, the button will pop out.
- A circuit can be reset by pushing the button in.

Final Circuit Check

Before resetting a circuit breaker, unplug all appliances from the electrical circuit which was disabled. Reset the proper breaker, and then plug each appliance in one at a time and observe the panel and appliance. If the circuit breaker trips, that particular appliance must be unplugged and repaired. If everything works properly, the circuit was probably overloaded with too many items plugged into it.

Replacement of Wall Switches and Receptacles

The instructions in this section describe a typical method for replacing a wall switch or an outlet. Before discussing the instructions, however, make sure you are familiar with the following tools and color codes.

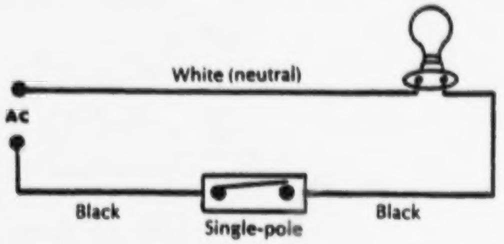
Common tools to use

Screwdriver
Phillips screwdriver
Long-nose pliers
Knife

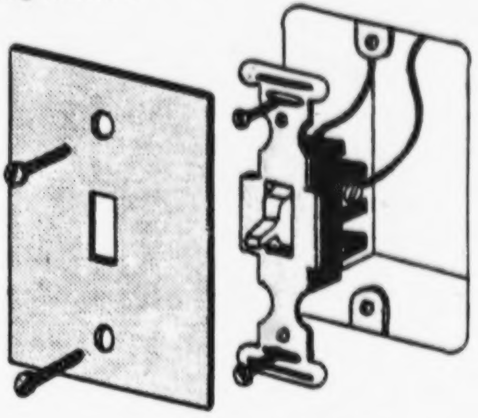
Electrical wire color code	Device screw color code
Green	Green
Red	Brass
White	Silver
Black	Brass
Bare wire	Electrical box (Ground)

Wall Switches

Wall switches sometimes wear out or short out; sometimes, they are just replaced with different kinds of switches. The following is a procedure for replacing switches:



1. Shut off the power at the panel.
2. Remove the cover plate.
3. Remove the mounting screws.
4. Pull the switch from the box.
5. Remove the two wires from the old switch.
6. Attach the two wires you just removed to the two terminals on the new switch (either order is acceptable).
7. Tighten the terminal screws.
8. Remount the switch in the box and replace the cover plate.
9. Restore the power.



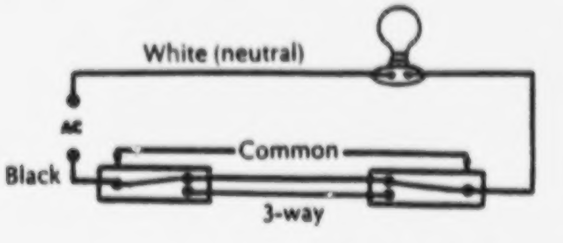
Single-pole switch
two terminal screws

(Green wire
not included
in description.)

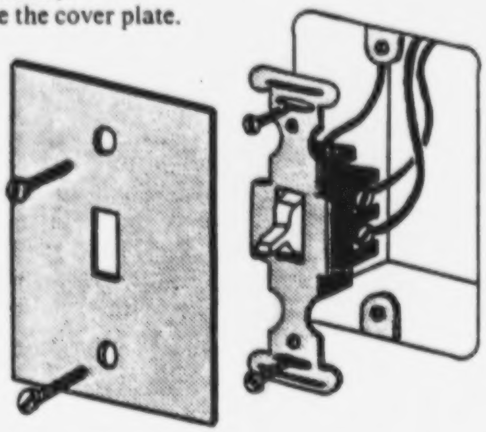
For a three-way switch, follow steps 1–4 above and then the following five steps:

5. Identify the terminal on the old switch that is marked common or that is a different color from that of the remaining two terminals. (All switches do not look alike.)
6. Remove the wire from the common terminal of the old switch and attach it to the common terminal on the new switch.

7. Now, remove the remaining two wires from the old switch and attach them to the remaining two terminals on the new switch (either order is acceptable).
8. Remount the switch in the switch box and replace the cover plate.
9. Restore the power.



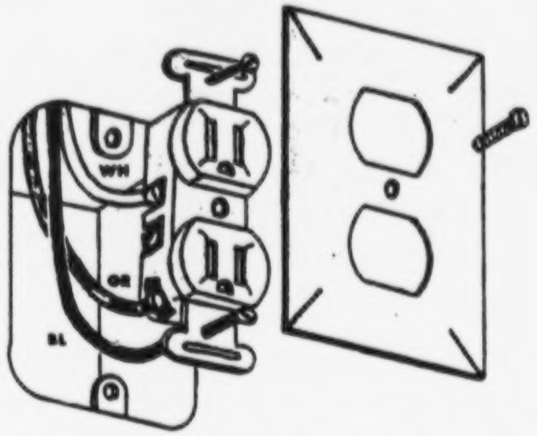
Three-way switch
Three terminal screws



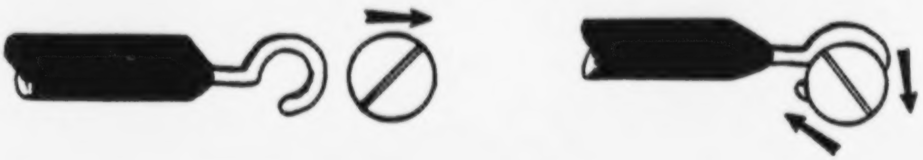
Wall Receptacles

Receptacles or outlets sometimes wear out or short out or are replaced with a different kind of receptacle. Use the following procedure to install receptacles:

1. Shut off the power at the panel.
2. Remove the cover plate.
3. Remove the mounting screws.
4. Pull the outlet from the box.
5. Loosen the terminal screws and remove the wires (or wire nuts).
6. Exchange the outlets.
7. Install the wires on the proper screws while observing the color code (black wire to brass screw, white wire to silver screw, and green wire to green screw).
8. Make sure that a black wire is not connected to a white wire.
9. Mount the outlet in the box and replace the cover plate.
10. Restore the power.



Always make sure the wires are carefully attached to the terminals of electrical devices. Place the bare loop around the screw so that it will be tightened by the clockwise motion when the screw is driven.



Switches are installed properly only when they make or break the "hot" (black) wire. The neutral (white) wire must never be interrupted by a switch.

Unlike with switches, wire coloring is always critical in electrical receptacles, so never connect wires of a different color to each other or to the same terminal.

Answer Key
for Unit 20

	T	F		
	1	2	3	4
1.		■		
2.		■		
3.		■		
4.	■			
5.		■		
6.		■		
7.	■			
8.		■		
9.	■			
10.	■			
11.		■		
12.		■		
13.		■		
14.	■			
15.		■		
16.	D			
17.	I			
18.	A			
19.	P			
20.	H			
21.	O			
22.	Q			
23.	L			
24.	C			
25.	K			

	T	F		
	1	2	3	4
26.	N			
27.	B			
28.	E			
29.	J			
30.	G			

Word Search

1. Conservation
2. Conduit
3. Grounded
4. Lamp socket
5. Line cord
6. AC plug
7. Armored cable
8. Boxes
9. Kilowatt-hour
10. Neutral wire
11. Receptacle
12. Service drop
13. Three-way switch
14. Wire gauge
15. Wall switch
16. Hot wire
17. Distribution
18. Electric

Activity

1. 43,216 kilowatt-hours
2. 1,573 kilowatt-hours
3. 8,057 kilowatt-hours
4. 49,417 kilowatt-hours

5A. Jan. 31—7,273
Dec. 31—6,842

5B. $10.65

$$\begin{array}{rl} 7{,}273 & \\ \underline{-\ 6{,}842} & \\ 431 & \text{kilowatt-hours} \\ \underline{\times\ \$0.021} & \text{per kilowatt-hour} \\ 431 & \\ \underline{862} & \\ 9.051 & \\ \underline{+\ 1.60} & \text{service charge} \\ \$10.65 & \text{total cost} \end{array}$$

6A. Black/red
6B. Green
6C. White

7. The hot lead to the right-side brass terminal; the neutral lead to the left-side silver terminal; the ground bare lead to the green grounding terminal
8. Route the hot lead from the source into the outlet box and wire-nut it to the black lead of a second two-wire cable running to the switch. Route the white lead from the source into the outlet box and wire-nut it to the white lead of the light socket. Wire-nut the remaining wire in the two-wire cable in the outlet box to the black lead of the socket. The two-wire cable is routed into the switch box, one wire is connected to either switch terminal, and the remaining wire is connected to the other terminal. The ground lead from the source is connected to a screw in the outlet box.

9A. Three-way switch
9B. Hot
9C. White
9D. Common connection

10. A three-way switch circuit makes it possible to turn a light on or off from two different locations.

Unit 21

Basic Electronics Mathematics

Title of Unit: Basic Electronics Mathematics

Time Allocated: Two weeks

Unit Goal

To investigate and reappraise students' mathematical competencies acquired in previous courses and to use those skills as a basis for introducing the principles of technical mathematics

Unit Objectives:

The student will be able to do the following:

1. Demonstrate through problem solving the proper procedures to follow when completing addition, subtraction, multiplication, and division problems.
2. Apply the theory of scientific notation or "powers of 10" and successfully work a variety of problems, as provided by the instructor.
3. Manipulate the decimal point correctly when converting common subunits (decimal multipliers) to other units.

Evaluation

The student will demonstrate his or her competence in the unit objectives on the basis of performance criteria established by the individual instructors. The criteria may include a combination of written, oral, and laboratory testing procedures.

Instructor's References

Cooke, Nelson, M., and others. *Basic Mathematics for Electronics* (Fifth edition). New York: McGraw-Hill Book Co., 1982.

Levine, Samuel. *Vocational and Technical Mathematics in Action.* Rochelle Park, N.J.: Hayden Book Co., 1969.

Singer, Bertrand B. *Basic Mathematics for Electricity and Electronics.* New York: McGraw-Hill Book Co., 1978, chapters 1–3.

Overview

The instructor has to assume that basic mathematics was taught to the students prior to this course. This unit is designed to review the competencies of basic mathematics and to teach students other related mathematics that will support further technical achievement.

The beginning thrust of this unit, then, is important, because such a review will quickly reestablish the mathematical skills of many students.

The topic of scientific notation may take a substantial amount of class time during instruction; however, the skill gained in handling numbers will be a valuable asset for the students.

Next, the students should review mathematical conversions. The importance of this topic cannot be overstated. Use many practice sessions, and remember that "repetition is the mother of learning."

Suggested Presentation Hints/Methodology

Use this unit as a basic guideline for presenting the curriculum; however, note the following:

1. A pretest (Activity) can be used just to review the meaning and processes of addition, subtraction, multiplication, division, fractions, decimals, powers, and square roots. Analyze the results to determine what areas need to be reviewed in more detail. Without this kind of assistance, the student will encounter tremendous difficulty.
2. The final topic in this unit refers to the techniques of applying a formula. For some students this is their first exposure to the process of solving for an unknown quantity. The instructor can assist the student by examining the purpose of a formula and then drawing the analogy that a formula is like a cooking recipe, which enables one to obtain desired results by properly combining the correct ingredients.

Supplemental Activities and Demonstrations

The following supplemental activities and demonstrations are suggested for use in presenting the curriculum:

1. A classroom computer, such as a TRS-80 or PET, can be used to reinforce the learning of basic mathematics. Program some challenging exercises that will increase the proficiency and mathematical power of the user.
2. The following is a fun-type activity which demonstrates the usefulness of scientific notation

and can be adapted to a game situation: Divide the chalkboard into two parts and ask a student to stand on one side. Write several large numbers to be multiplied as quickly as possible. In the meantime, move to the unused section of the chalkboard and, using scientific notation, complete the same problem. You should finish long before the students. This activity will impress them with the quickness of the technique.

Instructional Unit Contents

1. Unit Outline (overhead)
2. Pretest and Post-test (keyed)
3. Technical Glossary
4. Work Sheet (vocabulary)—Scrambled Word Puzzle
5. Work Sheet—Scientific Notation
6. Work Sheet—Multiplication and Divison Using Scientific Notation
7. Work Sheet—Electrical Units and Conversions
8. Activity
9. Informational Handout (Scientific Notation)
10. Informational Handout (Conversion of Electrical Units)
11. Informational Handout (Basic Mathematical Formulas)
12. Answer Key for Unit 21

Unit 21

Basic Electronics Mathematics

(Lecture Outline)

A. Review of Basic Mathematical Skills

B. Scientific Notation

C. Conversion of Electrical Units
   1. Common subunits and prefixes—kilo-, mega-, milli-, and so on
   2. Conversion method

D. Techniques in Applying a Formula

Test number ________

Examination for Unit 21

Basic Electronics Mathematics

Write your answers to the questions on the answer sheet. Fill in the box that corresponds to the correct answer to the question. Each question has only one correct answer.

1. The symbol for milli- is m. (T-F)
2. One hundred kilovolts is greater than 1 megavolt. (T-F)
3. The expression 1.5×5^{10} is a scientific notation expression. (T-F)
4. The electrical units volts, amperes, and ohms are considered basic units. (T-F)
5. One microvolt is equivalent to 0.000001 volts. (T-F)
6. The expression $X = 10 + y^2$ is a mathematical formula. (T-F)
7. In a conversion from kilo- to base, the decimal point should be moved three places to the left. (T-F)
8. In the multiplication of numbers written in scientific notation, one should add the exponents together. (T-F)
9. The prefixes milli-, micro-, mega-, and pico- represent numbers less than zero. (T-F)
10. Pico- is equivalent to 10^{-9}. (T-F)

Convert the following scientific notations to regular numbers:

11. $4.57 \times 10^3 =$ ____________
12. $7.3 \times 10^{-3} =$ ____________
13. $2.5 \times 10^0 =$ ____________

Convert the following regular numbers to scientific notations (use proper form):

14. 560,000 = ____________
15. 0.0089 = ____________
16. 555 = ____________

Solve the following problems:

17. $$\begin{array}{r} 1.4 \times 10^{6} \\ \underline{\times 8.9 \times 10^{-3}} \end{array}$$

18. $$\frac{6.5 \times 10^{7}}{5 \times 10^{-3}}$$

Perform the following conversions:

19. Convert 2,500 ohms to kilohms.

20. Convert 0.005 amp to milliamps.

21. Convert 450 microvolts to volts.

22. Convert 8,900 picoamps to microamps.

23. Convert 0.6 megohm to ohms.

24. Convert 20 millivolts to volts.

25. Given the formula $y = \frac{A \times B}{5}$,

solve for y if A = 5 and B = 15.

y = ___________

Technical Glossary

Basic unit—The fundamental measurement written without symbols or prefixes. For example, volts, ohms, and amperes are basic units, and millivolts, microamps, and kilohms are not basic units. The unit 3k ohms can be expressed as 3,000 ohms, which is a basic value. The symbols for the basic units listed above are V (volts), Ω (ohms), and A (amperes).

Conversion—The process of changing a number or expression from one form to an equivalent form. For example, the number 5,000 converted to scientific notation is expressed as 5×10^3.

Decimal point—A dot or point which separates the whole number from the decimal fraction. The location of the decimal point establishes the value of the number, as in 57.25.

Exponent—The exponent of a number, called the base, indicates how many times the number is to be multiplied by itself. For example, 6^4 means $6 \times 6 \times 6 \times 6 = 1,296$. The exponent is written as a number to the right of and slightly above the base. If the exponent is negative, then the reciprocal of the base is multiplied by itself. (Example: The reciprocal of 6 is $\frac{1}{6}$.)

Formula—A mathematical rule or procedure written in the form of an equation or mathematical sentence which contains an equals sign (=) between the known and unknown values. For example, $E = I \times R$ explains how to find the value of E by multiplying the value of I by the value of R.

Kilo-—A prefix meaning 1,000 (thousand). The abbreviation for this value is k. For example, 15k means 15,000.

Mega-—The prefix meaning 1,000,000 (million). The abbreviation for this value is M. For example, 5M means 5,000,000.

Micro-—A prefix meaning 0.000001 (millionth). The abbreviation for the value is μ. For example, 6μ means 0.000006.

Milli-—The prefix meaning 0.001 (thousandth). The abbreviation for the value is m. For example, 3m means 0.003.

Nano-—A prefix meaning 0.000000001 (billionth). The abbreviation for the value is n. For example, 8n means 0.000000008.

Pico-—The prefix meaning 0.000000000001 (millionths of a millionth). The abbreviation for the value is p. For example, 4p means 0.000000000004.

Power of a number—The product of multiplying a number by itself as many times as is indicated by the exponent of the number. Powers of numbers can be used to abbreviate large numbers, such as 1,000,000 (10^6) or 0.000001 (10^{-6}). The numbers 10^6 and 10^{-6} are power-of-10 expressions.

Prefix—A metric symbol located just before the electrical unit and used as a shortcut in expressing numerical value. The five common prefixes in electricity/electronics are mega-, kilo-, milli-, micro-, and pico-. For example, 7kV (electrical unit) is equal to 7,000V.

Scientific notation—A method of expressing either very large or very small numbers by using a number from 1 through 9.999 . . . times a power of 10. For example, 2.4×10^5 is equivalent to the number 240,000.

Score ________ Name ____________________

Grade ________ Date ____________________

Period ____________________

Work Sheet

Scrambled Word Puzzle

Unscramble the letters below to find the electronics terms.

Example:

A. AEXEPML	A. EXAMPLE
1. LOIK	1. ____________
2. AGEM	2. ____________
3. ONNA	3. ____________
4. ILMLI	4. ____________
5. IRMCO	5. ____________
6. CPOI	6. ____________
7. MOFURAL	7. ____________
8. SINNOVRECO	8. ____________
9. NETPONXE	9. ____________
10. IERPXF	10. ____________
11. SCBIA NUTI	11. ____________
12. MCIEDLA TINOP	12. ____________
13. IIICCFSTEN TATNNIOO	13. ____________
14. WOPRE FO NET	14. ____________

Score ________ Name ______________________

Grade ________ Date ______________________

Period ______________________

Work Sheet

Scientific Notation

1. In the number 4^3, the number 3 is called an __________. 1. ______________
2. The product of multiplying a number by itself is called the __________ of the number. 2. ______________
3. What is the numerical value of the expression 3^3? 3. ______________
4. To be in proper form, a scientific notation uses a number from ______ through ______ times 10 to a power. 4A. ______________ 4B. ______________
5. In the conversion of the expression 7.6×10^{-3} to a regular number, the decimal point should be moved three places to the ______. 5. ______________

Convert the following numbers, which are expressed in scientific notation, to regular numbers:

6. 5×10^2 6. ______________
7. 4.65×10^4 7. ______________
8. 5×10^{-3} 8. ______________
9. 6×10^0 9. ______________
10. 3.3×10^{-5} 10. ______________
11. 9.5755×10^3 11. ______________
12. 2.125×10^{-2} 12. ______________

Convert the following regular numbers to proper scientific notations:

13. 300 13. ______________
14. 650,000 14. ______________
15. 0.0083 15. ______________
16. 0.100 16. ______________

17. 7

18. 0.000000000012

19. 0.0015

20. 386.5

17. ____________________

18. ____________________

19. ____________________

20. ____________________

Work Space

Score ________

Grade ________

Name ______________________

Date ______________________

Period ______________________

Work Sheet

Multiplication and Division Using Scientific Notation

Complete the following problems and record your results in the answer boxes. Show your work.

1. $\begin{array}{r} 5 \times 10^{3} \\ \underline{\times 2 \times 10^{2}} \end{array}$

2. $\begin{array}{r} 52 \times 10^{5} \\ \underline{\times 11 \times 10^{3}} \end{array}$

3. $\begin{array}{r} 3.6 \times 10^{-3} \\ \underline{\times \quad 5 \times 10^{-6}} \end{array}$

1. ________

2. ________

3. ________

4. $\begin{array}{r} 24 \times 10^{-12} \\ \underline{\times 1.2 \times 10^{6}} \end{array}$

5. $\dfrac{42 \times 10^{5}}{2 \times 10^{3}}$

6. $\dfrac{753 \times 10^{3}}{3 \times 10^{-3}}$

4. ________

5. ________

6. ________

7. $\dfrac{25 \times 10^{-9}}{4 \times 10^{6}}$

8. $\dfrac{1.56 \times 10^{-6}}{13 \times 10^{-3}}$

7. ________

8. ________

Score ________

Grade ________

Name ________________________

Date ________________________

Period ________________________

Work Sheet

Electrical Units and Conversions

Complete the chart below:

Unit	Symbol	Numerical value	Power of 10 equivalent
Mega-			
	k		
Basic unit			10^0
		0.001	
			10^{-6}
Nano-			
	p		

Use the conversion chart below to help you perform electrical unit conversions.

Mega-	Kilo-	Basic unit	Milli-	Micro-	Nano-	Pico-
10^6	10^3	10^0	10^{-3}	10^{-6}	10^{-9}	10^{-12}
M	k	*	m	μ	n	p

← Move the decimal point to the left.

Move the decimal point to the right. →

Perform the following electrical unit conversions. Write your answers in the spaces provided at the right.

1. 27,000,000 ohms is the same as ________ megohms. 1. ________________
2. 1 kilovolt is the same as ________ volts. 2. ________________
3. 2,000 milliamperes is the same as ________ amperes. 3. ________________

4. 0.1 megohm is the same as ________ ohms. 4. ________________

5. 9 amperes is the same as ________ milliamperes. 5. ________________

6. 600 millivolts is the same as ________ volt. 6. ________________

7. 250 microamperes is the same as ________ ampere. 7. ________________

8. 850 microvolts is the same as ________ millivolt. 8. ________________

9. 0.115 ampere is the same as ________ milliamperes. 9. ________________

10. 60 kilohms is the same as ________ megaohms. 10. ________________

11. 90 ohms is the same as ________ kilohms. 11. ________________

12. 49,000 picoamperes is the same as ________ microamperes. 12. ________________

13. 5,000 microvolts is the same as ________ volts. 13. ________________

14. 6 kilohms is the same as ________ ohms. 14. ________________

15. 0.75 volt is the same as ________ microvolts. 15. ________________

16. Convert 350,000Ω to kΩ. 16. ________________

17. Convert 0.005A to mA. 17. ________________

18. Convert 0.000061V to μV. 18. ________________

19. Convert 485,000V to mV. 19. ________________

20. Convert 75kΩ to Ω. 20. ________________

21. Convert 153mA to μA. 21. ________________

22. Convert 62pV to mV. 22. ________________

23. Convert 560Ω to kΩ. 23. ________________

24. Convert 150μA to A. 24. ________________

25. Convert 0.09V to kV. 25. ________________

Score ________ Name ________________________

Grade ________ Date ________________________

Period ________________________

Work Sheet

Activity

This activity is a review of basic mathematical skills. Do all your work in the spaces provided. Show your work on this paper and record your answers in the spaces provided at the right.

1. $$\begin{array}{r} 15 \\ 28 \\ 37 \\ \underline{+47} \end{array}$$

1. ________________

2. $2.27 + 0.84 + 390 =$

2. ________________

3. $8 + 8.8 + 88 + 0.8 =$

3. ________________

4. The sum of x and y can be written as:

A. xy B. $\frac{x}{y}$ C. $x - y$

D. $x + y$ E. None of these

4. ________________

5. $$\begin{array}{r} 8{,}976 \\ \underline{-4{,}735} \end{array}$$

5. ________________

6. $$\begin{array}{r} 4{,}837 \\ \underline{-2{,}548} \end{array}$$

6. ________________

7. $4.8 - 3.27 =$

7. ________________

8. Find the difference between 632 and 425.78.

8. ________________

9. $$\begin{array}{r} 73 \\ \underline{\times 61} \end{array}$$

9. ________________

10. $$\begin{array}{r} 2.08 \\ \underline{\times\ 2.3} \end{array}$$

10. ________________

11. $$\begin{array}{r} 0.3429 \\ \underline{\times\ 1{,}000} \end{array}$$

11. ________________

12. Which one of the following statements is true? 12. ____________

A. $6 \times 4 = 21$
B. $6 \times 0 = 6$
C. $0.6 \times 0.4 = 2.4$
D. $6 \times 4 = 4 \times 6$
E. $6 \times 4 = 0.24$

In problems 13 through 16 write any remainders as fractions.

13. $47\overline{)11,095}$ 13. ____________

14. $8,416 \div 8$ 14. ____________

15. $\frac{9,612}{27}$ 15. ____________

16. In the division problem $\overset{7}{6\overline{)42}}$, the number 7 is called the: 16. ____________

A. Divisor
B. Dividend
C. Quotient
D. Remainder
E. None of these

17. $3\overline{)0.69}$ 17. ____________

18. $0.018\overline{)3.6}$ 18. ____________

19. $0.44\overline{)11}$ 19. ____________

20. Which of the following cannot be done? 20. ____________

A. $32 \div 0$
B. $0 \div 14$
C. $27\overline{)0}$
D. $\frac{0}{7}$
E. All of these

In problems 21 through 30, reduce all fractions to lowest terms.

21. $\frac{1}{8} + \frac{1}{4} + \frac{3}{8} =$ 21. ____________

22. $1\frac{1}{16} + \frac{3}{64} + 4\,\frac{17}{32} =$ 22. ____________

23. $\frac{19}{64} - \frac{7}{32} =$

24. $19 - 2\frac{25}{64} =$

25. $\frac{2}{3} \times \frac{5}{3} =$

26. $1\frac{1}{4} \times 3\frac{1}{8} =$

27. $\frac{1}{8} \div \frac{3}{4} =$

28. $3\frac{2}{32} \div 1\frac{5}{64} =$

29. 4^3

30. $\sqrt{169}$

23. ______________________

24. ______________________

25. ______________________

26. ______________________

27. ______________________

28. ______________________

29. ______________________

30. ______________________

Informational Handout

Scientific Notation

Scientific notation is an easy shortcut for expressing very large or very small numbers containing many zeros to either the right or left of the decimal point. Numbers such as 100,000,000 or 0.0000000025 can easily be shortened by writing them in scientific notation form. In the multiplication or division of numbers containing many zeros, it is often difficult to keep track of the zeros and decimal points to arrive at a correct answer. However, scientific notation can help in solving these types of problems.

The following is an example of the power of scientific notation. Problem:

$$15{,}000{,}000 \times 6{,}200{,}000{,}000 =$$

If the standard multiplication method were used, the computations would look like this:

$$\begin{array}{r}
6{,}200{,}000{,}000 \\
\times \quad 15{,}000{,}000 \\
\hline
0000000000 \\
0000000000 \\
0000000000 \\
0000000000 \\
0000000000 \\
0000000000 \\
31000000000 \\
6200000000 \\
\hline
93000000000000000
\end{array}$$

But, if scientific notation were used, the problem would look like this:

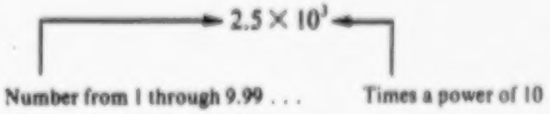
$$\begin{array}{l}
6.2 \times 10^{9} \\
\underline{1.5 \times 10^{7}} \\
31\,0 \\
\underline{62} \\
9.30 \times 10^{16} \quad \text{or} \quad 9.3 \times 10^{16}
\end{array}$$

As you can see, scientific notation uses powers of 10 to replace the zeros in the regular number. Study the following charts and try to find the relationship between the exponent of 10 and the decimal number.

Positive Powers of 10	Negative Powers of 10
$10^{0} = 1$	$10^{0} = 1$
$10^{1} = 10$	$10^{-1} = 0.1$
$10^{2} = 100$	$10^{-2} = 0.01$
$10^{3} = 1{,}000$	$10^{-3} = 0.001$
$10^{4} = 10{,}000$	$10^{-4} = 0.0001$
$10^{5} = 100{,}000$	$10^{-5} = 0.00001$
$10^{6} = 1{,}000{,}000$	$10^{-6} = 0.000001$

The exponent indicates how many places to move the decimal point. When a positive power is used, the decimal point is moved to the right; when a negative power is used, the decimal point is moved to the left.

Scientific notation, in proper form, uses a number from 1 through 9.99 . . . times a power of 10, as shown below:



Conversion of Scientific Notations to Regular Numbers

With knowledge of the powers of 10, it should be fairly simple to translate scientific notation to a regular number. For example, 2.5×10^{3} is the same as 2,500.

The rules for converting scientific notation to regular numbers are as follows:

1. If the scientific notation has a positive exponent, move the decimal point to the right the number of places indicated by the exponent.

   Example:

   $3 \times 10^{4} = 3\smile\smile\smile\smile$ or 30,000

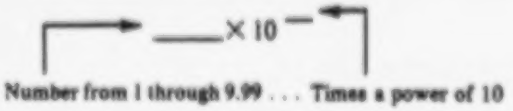
2. If the scientific notation has a negative exponent, move the decimal point to the left the number of places indicated by the exponent.

   Example:

   $2.1 \times 10^{-3} = \underbrace{\;.\;\;\;\;}2.1$ or 0.0021

Conversion of Regular Numbers to Scientific Notation

Converting a number such as 61,000 to scientific notation is a fairly simple job if you remember the basic form of a scientific notation number:



$\underline{\quad\quad} \times 10^{-}$
Number from 1 through 9.99 . . .
Times a power of 10

Thus, when converting to scientific notation, move the decimal point of the original number until you have only a number from 1 through 9.99 . . . to the left of the decimal point. Count the number of places you moved the decimal point; this number will be your exponent.

61000.

1. Begin at the decimal point.

   $6.\underbrace{1\,0\,0\,0}.$

2. Move the decimal point to here (the point at which a number from 1 through 9.99 . . . is at the left of the decimal point) and count the number of places the decimal point was moved.

   6.1×10^{4}

3. Write the number in scientific notation form. (Drop extra zeros; the exponent is equal to the number of decimal places moved.)

The rules for converting regular numbers to scientific notations are as follows:

1. If the original number is greater than 10, then move the decimal point to the left until you have only a number from 1 through 9.99 . . . to the left of the decimal point. The exponent of 10 is equal to the number of places the decimal point is moved and is given a positive sign.

   Example: Convert 5,600 to scientific notation:

   $5{,}600 = 5.\underbrace{6\,0\,0}. = 5.6 \times 10^{3}$

2. If the original number is less than 1, then move the decimal point to the right until you have only a number from 1 through 9.99 . . . to the right of the decimal point. The exponent is equal to the number of places the decimal point is moved and is given a negative sign.

   Example: Convert 0.00034 to scientific notation.

   $0.00034 = \underbrace{.0\,0\,0\,3}.4 = 3.4 \times 10^{-4}$

3. If the number is from 1 through 9.99 . . . leave it alone. Ten is written 1×10^{1}.

Multiplication Using Scientific Notation

Using scientific notation when multiplying or dividing greatly simplifies the task because you do not have to keep track of zeros or the number of decimal places. The following illustrates the procedure:

$$\begin{array}{r} 4 \times 10^{3} \\ \times\, 2 \times 10^{4} \\ \hline 8 \times 10^{7} \end{array}$$

To multiply using scientific notation, simply multiply the numbers together and add the exponents. Be sure to note the signs of the exponents.

The following are some other examples:

A. $$\begin{array}{r} 3 \times 10^{4} \\ \times\, 7 \times 10^{-3} \\ \hline 21 \times 10^{1} \end{array} \quad \text{OR} \quad 2.1 \times 10^{2}$$

B. $$\begin{array}{r} 2 \times 10^{-2} \\ \times\, 8 \times 10^{-1} \\ \hline 16 \times 10^{-3} \end{array} \quad \text{OR} \quad 1.6 \times 10^{-2}$$

C. $$\begin{array}{r} 4.1 \times 10^{-6} \\ \times\quad 5 \times 10^{4} \\ \hline 20.5 \times 10^{-2} \end{array} \quad \text{OR} \quad 2.05 \times 10^{-1}$$

Division Using Scientific Notation

Division using scientific notation is also a simple process. Study the following example and see whether you can figure out the system:

$$\frac{8 \times 10^{5}}{2 \times 10^{2}} = 4 \times 10^{3}$$

Did you understand the above? To divide, write the expressions as a fraction. Divide the numbers as you normally would, change the sign of the exponent on the bottom, and add the bottom exponent to the exponent on the top.

The following are some other examples:

A. $$\frac{15 \times 10^{6}}{3 \times 10^{4}} = \frac{15}{3} = 5 \times 10^{\begin{array}{r}+6\\-4\\\hline 2\end{array}} = 5 \times 10^{2}$$

B. $$\frac{14 \times 10^{-3}}{7 \times 10^{2}} = \frac{14}{7} = 2 \times 10^{\begin{array}{r}-3\\-2\\\hline -5\end{array}} = 2 \times 10^{-5}$$

C. $$\frac{25 \times 10^{1}}{5 \times 10^{-3}} = \frac{25}{5} = 5 \times 10^{\begin{array}{r}1\\+3\\\hline 4\end{array}} = 5 \times 10^{4}$$

D. $$\frac{36 \times 10^{-4}}{4 \times 10^{-2}} = \frac{36}{4} = 9 \times 10^{\begin{array}{r}-4\\+2\\\hline -2\end{array}} = 9 \times 10^{-2}$$

Informational Handout

Conversion of Electrical Units

Six common prefixes or subunits are used with electrical measurements. These units (mega-, kilo-, milli-, micro-, nano-, and pico-) provide a simple method for expressing very large or very small numbers without having to use scientific notation. Study the chart below and learn the meaning and relationship between the various units.

Prefix	Abbreviation	Power of 10 equivalent	Numerical value
Mega-	M	10^6	1,000,000
Kilo-	k	10^3	1,000
Basic Unit (volts, amps, ohms, and so forth.)		10^0	1
Milli-	m	10^{-3}	0.001
Micro-	μ	10^{-6}	0.000001
Nano-	n	10^{-9}	0.000000001
Pico-	p	10^{-12}	0.000000000001

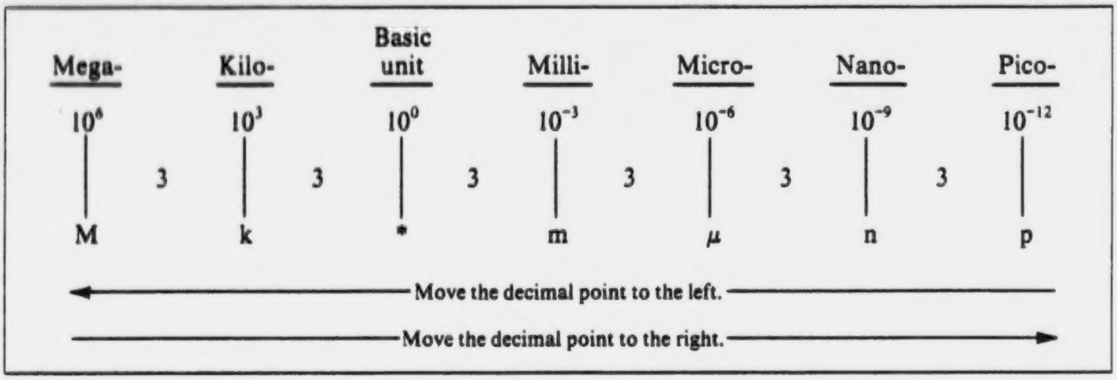
Thus: 1M is equal to 1×10^6 or 1,000,000.
2kV is the same as 2×10^3V or 2,000V.
3mA can be written as 3×10^{-3}A or 0.003A.
4μV is equal to 4×10^{-6}V or 0.000004V.
5nA is the same as 5×10^{-9}A or 0.000000005A.
6pV can be written as 6×10^{-12}V or 0.000000000006V.

Often, it is necessary to convert from one electrical unit to another, especially when working with basic electrical formulas which require the electrical quantities to be in basic units or similar units (all in milli-, micro-, and so on).

How would you convert 3kV to a basic unit, or volts? If you recall, kilo- means thousand or 10^3; therefore, 3kV = 10^3 volts or 3,000V. All that was done to convert from kilo- to base was to move the decimal point three places to the right (3kv = 3$\smile\smile\smile$= 3,000V). Likewise, to change 3,000V to kilovolts, the decimal point was moved three places to the left (3,000V = 3 $\smile\smile\smile$ = 3kV). Thus, the process of converting from one electrical unit to another simply involves moving the decimal point to the left or to the right a certain number of places.

The chart below can be used as an aid in performing electrical unit conversions. Notice that there are three decimal places between each unit.

Conversion Chart



Conversion Steps

When converting from one unit to another unit, do the following:

1. Count the number of decimal places from the original unit to the desired unit. (Remember, there are three decimal places between each unit.)
2. Determine the direction the decimal point will move. The decimal point will be moved in the same direction that you read across the chart, from your original unit to your final unit. For example, if you are converting from kilo- to milli-, the decimal point will be moved to the right, but if you are converting from micro- to the basic unit, the decimal point will be moved to the left.
3. Move the decimal point the number of places counted in Step 1 and in the direction determined in Step 2.

Sample Conversions

A. 25,000 ohms is the same as how many kilohms?

The problem is to convert 25,000 ohms (basic unit) to kilohms (kilo-). Looking at the chart, count the number of decimal places between the basic unit and kilo-. You should count three decimal places. When counting, you start at the basic unit and move to kilo-, which takes you to the left across the chart; thus, you will move the decimal point to the left. With this information, you can complete the conversion as follows:

$$25{,}000\Omega = 25.\underbrace{0\ 0\ 0.} = 25\text{k}\Omega$$

B. Convert 0.007A to mA.

Procedure: Move from the basic unit (A) to milli-, which is three places to the right across the chart; thus, $0.007\text{A} = \underbrace{0.0\ 0\ 7.} = 7\text{mA}$.

C. Convert 4.3μV to kV.

Procedure: Move from μ to k across the chart, which is nine decimal places to the left; thus, $4.3\mu\text{V} = 0.\underbrace{0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 4}.3 = 0.0000000043\text{kV}$.

Informational Handout

Basic Mathematical Formulas

$$y = \frac{10 + z}{A}$$

The above statement is a mathematical formula that shows how to obtain a desired result from a mixture of numbers and terms.

A formula may be thought of as a mathematical recipe. By properly combining different ingredients (numbers, operations, or variables), you can obtain the desired result or correct answer.

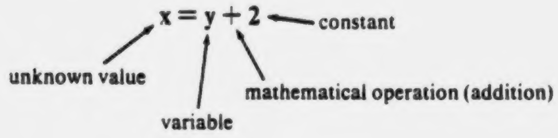
A formula shows you what to do. A mathematical formula shows you, for example, when to add, subtract, multiply, or divide.

Formulas can be simple statements, such as $y = 10 + 6$ (which means that the value of y can be found by adding 10 and 6), or very complex expressions, such as $R = 7A^2 + 6A - 10$ (which means that the value of R can be found by first squaring the value A, then multiplying that by 7, next adding the result to 6 times A, and finally subtracting 10).

Both simple and complex formulas have the following in common:

1. *Unknown value:* Generally abbreviated with a letter and located by itself on the left side of the equal sign. This is the value you are trying to find.
2. *Variable:* A number, also abbreviated as a letter, and generally located on the right side of the equal sign. A variable can be assigned many different values.
3. *Constant:* A number with a fixed value.
4. *Mathematical operation:* The computation to be performed: multiplication, division, addition, or subtraction.

Example:



Study the following sample problems and learn how to use a simple formula.

1. Solve for R in the formula below, given that $y = 6$.

$R = 4 + y$

Step 1. Substitute the given value of y in the formula.

$R = 4 + 6$

Step 2. Perform the mathematical function of addition.

$R = 10$

Step 3. Record the solution.

2. Solve for Q in the formula below, given that $S = 10$ and $D = 5$.

$Q = (2 \times S) + D$

Step 1. Substitute the given values of S and D in the formula.

$Q = (2 \times 10) + 5$

Step 2. Perform the multiplication.

$Q = 20 + 5$

Step 3. Perform the addition.

$Q = 25$

Step 4. Record the solution.

3. Solve for E in the formula below, given that $I = 5$ and $R = 100$.

$E = I \times R$

$E =$

$E =$

Answer: $\overline{\text{00S}}$

Answer Key
for Unit 21

	T	F		
	1	2	3	4
1.	■			
2.		■		
3.		■		
4.	■			
5.	■			
6.	■			
7.		■		
8.	■			
9.		■		
10.		■		
11.	457			
12.	0.0073			
13.	2.5			
14.	5.6×10^5			
15.	8.9×10^{-3}			
16.	5.55×10^2			
17.	1.24×10^4			
18.	1.3×10^{10}			
19.	2.5 kilohms			
20.	5 milliamps			
21.	0.00045 volts			
22.	0.0089 microamps			
23.	600,000 ohms			
24.	0.02 volt			
25.	y = 15			

Scrambled Word Puzzle

1. Kilo
2. Mega
3. Nano
4. Milli
5. Micro
6. Pico
7. Formula
8. Conversion
9. Exponent
10. Prefix
11. Basic unit
12. Decimal point
13. Scientific notation
14. Power of ten

Scientific Notation

1. Exponent
2. Power
3. 27

4A. 1

4B. 9.99 . . .

5. Left
6. 500
7. 46,500
8. 0.005
9. 6
10. 0.000033
11. 9,575.5
12. 0.02125
13. 3×10^2
14. 6.5×10^5
15. 8.3×10^{-3}
16. 1×10^{-1}
17. 7×10^0
18. 1.2×10^{-11}
19. 1.5×10^{-3}
20. 3.865×10^2

Multiplication and Division Using Scientific Notation

1. 1×10^6
2. 5.72×10^{10}
3. 1.8×10^{-8}
4. 2.88×10^{-5}
5. 2.1×10^3
6. 2.51×10^8
7. 6.25×10^{-15}
8. 1.2×10^{-4}

Electrical Units and Conversions

(For answers to the chart conversion exercise, see page 307.)

1. 27
2. 1,000
3. 2
4. 100,000
5. 9,000
6. 0.6
7. 0.00025
8. 0.85
9. 115
10. 0.06
11. 0.09
12. 0.049
13. 0.005
14. 6,000
15. 750,000
16. 350k ohms
17. 5mA
18. 61μV
19. 485,000,000mV
20. 75,000 ohms
21. 153,000μA
22. 0.000062mV
23. 0.56k ohms
24. 0.00015A
25. 0.00009kV

Answer Key for Unit 21—Continued

Activity

1. 127
2. 393.11
3. 105.6
4. D
5. 4,241
6. 2,289
7. 1.53
8. 206.22
9. 4,453
10. 4.784
11. 342.9
12. D
13. 236-3/47
14. 1,052
15. 356
16. C
17. 0.23
18. 200
19. 25
20. A
21. 3/4
22. 5-41/64
23. 5/64
24. 16-39/64
25. 5/12
26. 3-29/32
27. 1/6
28. 2-58/69
29. 64
30. 13

Unit 22

Communication Systems

Title of Unit: Communication Systems

Time Allocated: Two weeks

Unit Goal

To provide the student with a general overview of the importance and purpose of basic communication systems

Unit Objectives

The student will be able to do the following:

1. Explain early human beings' desire to communicate with others and describe a variety of ancient long-distance communication systems.
2. Identify nine fundamental communication systems and briefly indicate their general methods of operation.
3. Summarize the sequence of elements or processes that are involved in any basic communication system.

Evaluation

The student will demonstrate his or her competence in the unit objectives on the basis of performance criteria established by the individual instructors. The criteria may include a combination of written, oral, and laboratory testing procedures.

Instructor's References

Buban, Peter, and Marshall L. Schmitt. *Understanding Electricity and Electronics*. New York: McGraw-Hill Book Co., 1976.

Rollain, Philip J., and Thomas E. Kraus. *Exploring Electricity and Electronics with the Electrical Team.* Albany, N.Y.: Delmar Publishers, 1979.

Shrader, Robert L. *Electronic Communication* (Fifth edition). New York: McGraw-Hill Book Co., 1985.

Overview

The individual topics in this unit should be prefaced with an overview of the evolution of communication. Then, present the essential components of the communication process, which include the message source, coder, carrier decoder, and message destination.

Next, work through each topic title in the unit and present a brief explanation; note that these topics should be covered in a manner that will promote general technical understanding.

Suggested Presentation Hints/Methodology

Use this unit as a basic guideline for presenting the curriculum; however, note the following:

1. This unit was included to encourage the students to continue their studies; therefore, instructors should not dwell too much on technical specifics but rather should stress concepts for the application of each type of communication system.
2. In a discussion of the first long-distance communication system (telegraph), it might be helpful to compare its operation and components with those of any other communication system (message-source, key-coder, wire-carrier, sounder-decoder, and operator-destination). Use this technique for each system topic that is discussed.
3. This unit provides an ideal opportunity to explain the purpose of the Federal Communications Commission (FCC). The FCC is a governmental agency that regulates all wave transmissions in the United States. Have the class explain why such an agency is necessary.
4. The need for a discussion of the computer as a system within the chain of communication devices is obvious. However, the following additional topics should initiate some interesting conversations:

   People communicating with computers

   Computers communicating with people

   Computers communicating with other computers

Supplemental Activities and Demonstrations

The following supplemental activities and demonstrations are suggested for use in presenting the curriculum:

1. Write to the National Aeronautics and Space Administration (NASA). The educational and informational publications of NASA are designed

to meet the needs of both students and educators. A listing of NASA materials and their costs can be ordered from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

2. Have the students make a poster that depicts one or more of the communication systems discussed. Display the posters.
3. Emphasize that interference can disrupt even the most sophisticated communication system. Place a buzzer close to a TV and activate both while the students observe the TV screen. Discuss the results.

Instructional Unit Contents

1. Unit Outline (overhead)
2. Pretest and Post-test (keyed)
3. Technical Glossary
4. Work Sheet (vocabulary)—Know Your Definitions
5. Work Sheet—Elements of Communication Systems
6. Activity
7. Informational Handout (History of Communication Systems)
8. Answer Key for Unit 22

Unit 22

Communication Systems

(Lecture Outline)

A. Evolution of Communication Systems

B. Telegraph

C. Telephone

D. Radio

E. Television

F. Radar

G. Microwave

H. Satellites

I. Lasers

J. Computers

Test number__________

Examination for Unit 22

Communication Systems

Write your answers to the questions on the answer sheet. Fill in the box that corresponds to the correct answer to the question. Each question has only one correct answer.

1. The person who starts the communication process or system is called the message or informational source. (T-F)
2. A communication system has five basic parts or elements. (T-F)
3. A telegraph key is a communication device that translates electric pulses into mechanical action. (T-F)
4. A television receiver is a communication device in which visual images are translated into electric current. (T-F)
5. The decoding element of a communication system changes data or information into a form that is meaningful to the recipient of the message. (T-F)
6. An audio reproducer is the technical name for a microphone. (T-F)
7. Vladimir Zworykin was one of the developers of the television communication system. (T-F)
8. An antenna is a very important element in a cable television receiver system. (T-F)
9. The letters FCC are an abbreviation for a noncommercial radio station in Washington, D.C. (T-F)
10. A radar system transmits signals that strike an object and bounce off it, thus creating a receivable echo. (T-F)
11. How many transmitters are used in a television broadcasting station?

    1. 1
    2. 2
    3. 3
    4. 4

12. A laser beam is usually considered a brilliant-red beam of ________ light.

    1. Electromagnetic
    2. Infrared
    3. Coherent
    4. Incoherent

13. The ________ stage of a computer holds information for future processing.

    1. Storage
    2. Logic
    3. Control
    4. Output

14. Radio waves travel at ________, and they travel in every direction from an antenna.

    1. The speed of sound
    2. About 50 to 200 mph
    3. 600,000 Hz
    4. 186,000 mps

15. The first satellite launched by the Russians was called:

1. *Beatnik*	3. *Sputnik*
2. *Spacenik*	4. *Firstnik*

16. When a television transmitter and receiver are locked in step, they are in ________

17. Satellites generally generate their own operating power from ________ energy; however, power demands are not really that great because the ground radio receiving stations are now so sensitive and accurate that only a small signal need be transmitted.

18. Two of the human senses used in the communication process between people are speaking and ________.

19. In telegraph communication, the process of attaching meaning to dots and dashes heard from the decoder element is the function of the ________ element.

20. ________ commercial radio broadcast stations operate on a band of frequencies ranging from 535kHz to 1,605kHz.

Technical Glossary

Antenna—A device, consisting of a pattern of wires or conducting rods, used either to send (radiate) or pick up (receive) radio waves.

Carrier—The medium or device used to move or carry information from one location to another. In a radio system, for example, the carrier is high-frequency AC waves or radio waves.

Coder—A device or circuit used to shape or convert information into the proper form for transmission.

Communication—The process of sending (transmitting) and acquiring (receiving) understandable information.

Computer—An electric device able to accept information and then process or work on that information and supply data or results. A computer usually consists of an input and output device, storage or memory circuits, arithmetic/logic units, and a control unit.

Data—A term used to describe information, facts, or figures.

Decoder—A device or circuit used to separate the information from the carrier of a transmitted signal. The decoder reproduces the original message.

Detection—In a communication system, the process of separating the intelligence or information from the carrier.

Information—The facts, data, programming, or intelligence added to the carrier to make up a transmitted signal.

Laser—An electronic device which emits a tight beam of light that is extremely intense and highly directional. Lasers can be used to cut materials, align items, measure distances, and communicate.

Microwave—An extremely short length, ultrahigh frequency radio wave which travels at the speed of light and in a straight line. Microwaves can be used to carry information as well as to heat and cook food.

Modulation—The process of mixing the intelligence or information with the carrier in preparation for transmission.

Radar—A transmission system that uses bursts of high frequency electrical energy at a set frequency, duration, and direction. If the projected wave strikes an object, an echo is sent back which is used to determine the location and distance of the object.

Radio—A communication system that uses radio waves of a set frequency to carry information from the transmitter to an antenna, through the air waves to a receiving antenna, and finally to the receiver and listener. Radio was the first wireless communication system capable of transmitting and receiving voice signals.

Radio wave—High frequency electrical energy capable of traveling great distances through the air and also able to carry information. Radio frequency (RF) waves range from 20,000 cycles per second to 30,000,000,000 cycles per second.

Satellite—An automated spacecraft capable of performing specific tasks while orbiting the earth. Basically, satellites are able to gather information, process that information, and transmit and receive data.

Sync—The process of timing or setting two or more actions to occur at the same instant. For example, in a television system the sound and picture signals must be in sync to coordinate voice and mouth movements or sound with actions.

Telegraph—An early communication system that uses a wire to carry electrical pulses from one location to another. A key is used to produce and transmit a series of pulses (dots and dashes) which are received and reproduced by a sounder. The operator must then translate the coded message into understandable language.

Telephone—A practical communication system able to transmit and receive voice and sound signals by means of electrical impulses traveling through interconnecting wires. The transmitting device is a microphone located in the mouthpiece of the hand set, while the receiving device consists of a vibrating diaphragm located in the earpiece.

Television—Generally, a wireless communication system which is capable of transmitting simultaneously video (picture) and audio (sound) signals on a radio wave carrier. When the TV signal is captured by the receiving antenna and fed to the receiver, the signal converted back to visual pictures with synchronized sound.

Score ________

Grade ________

Name ________________________

Date ________________________

Period ________________________

Work Sheet

Know Your Definitions

Short definitions are presented below for a number of electrical terms. Determine the term that best fits each definition. The Technical Glossary may be used to find the definitions of some of the more difficult terms. Write your answers in the spaces provided.

	Definition		Term
Example:			
A.	The basic unit for measuring current	A.	Ampere
1.	The process for transmitting and receiving understandable information	1.	________________
2.	A device or circuit used to separate the information from the signal carrier	2.	________________
3.	A system that uses bursts of electrical energy to determine the location and distance of an object	3.	________________
4.	High frequency electrical energy capable of carrying information through the air for great distances	4.	________________
5.	A system of communication that use both video and audio signals carried by radio waves	5.	________________
6.	The process of timing two actions to occur at the same instant	6.	________________
7.	The medium or device used to move information from one location to another	7.	________________
8.	The process of mixing the signal information with the carrier	8.	________________
9.	A device which produces an extremely intense, highly directional, tight beam of light	9.	________________
10.	A communication system capable of sending information over a wire in the form of electrical pulses (dots and dashes)	10.	________________
11.	The facts, data, programming, or intelligence added to the carrier	11.	________________
12.	Extremely short, ultrahigh frequency radio waves which travel at the speed of light and in a straight line	12.	________________

Score ________ Name ______________________

Grade ________ Date ______________________

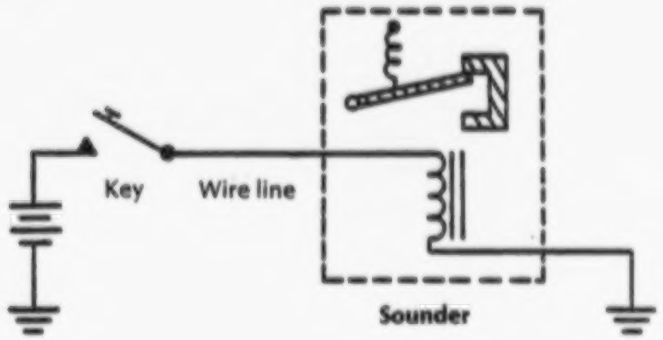
Period ______________________

Work Sheet

Elements of Communication Systems

Communication plays a vital role in our lives. The systems developed to transmit information from person to person are consistently being improved, modified, or replaced with more efficient systems. Modern day communication systems use techniques such as radio wave, microwave, and laser-light beam transmissions. The following pages contain descriptions of communication systems which should be completed and documented. Follow the example given below and include a sketch or a block diagram of each system, when possible, along with the communication system elements.

Telegraph System



Facts:

System and inventor(s): The telegraph system was patented in 1843 by Samuel Morse.

Basic operation: A hand-operated switch (key) controls pulses of current (dots and dashes) which are assigned alphanumeric meanings.

System elements:

Source: Message content

Coder: Telegraph key

Message carrier: Wire/electricity

Decoder: Telegraph sounder

Message destination: Electrical pulses are converted to sound waves, received by human ears, and translated by the brain.

Radar System

Facts:

Source:
Coder:
Message carrier:
Decoder:
Message destination:

Laser System

Facts:

Source:
Coder:
Message carrier:
Decoder:
Message destination:

Television System

Facts:

Source:
Coder:
Message carrier:
Decoder:
Message destination:

Microwave System

Facts:

Source:
Coder:
Message carrier:
Decoder:
Message destination:

Score ________

Grade________

Name ____________________

Date ____________________

Period ____________________

Work Sheet

Activity

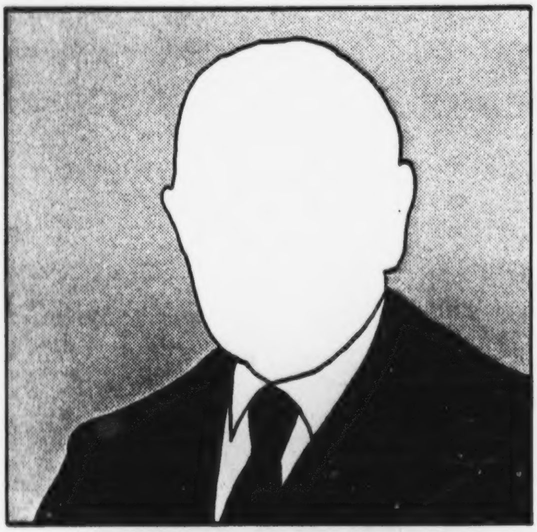
Using the biographical clues below, identify this individual. The school library or an encyclopedia can be used as an information source.

Fill in the names of the books that you used to complete this activity:

1. ____________________

2. ____________________

3. ____________________



Who Am I?

- Moved to the United States in 1920
- Developed the iconoscope tube
- Born in 1889
- Physicist
- Worked for RCA
- Attended Petrograd Institute of Technology
- Pioneer in the discovery of TV
- Worked for Westinghouse
- Inventor/engineer
- Assisted in the development of the electron microscope
- Holds over 120 patents
- Received the National Medal of Science Award
- Raised in Russia
- Created the kinescope

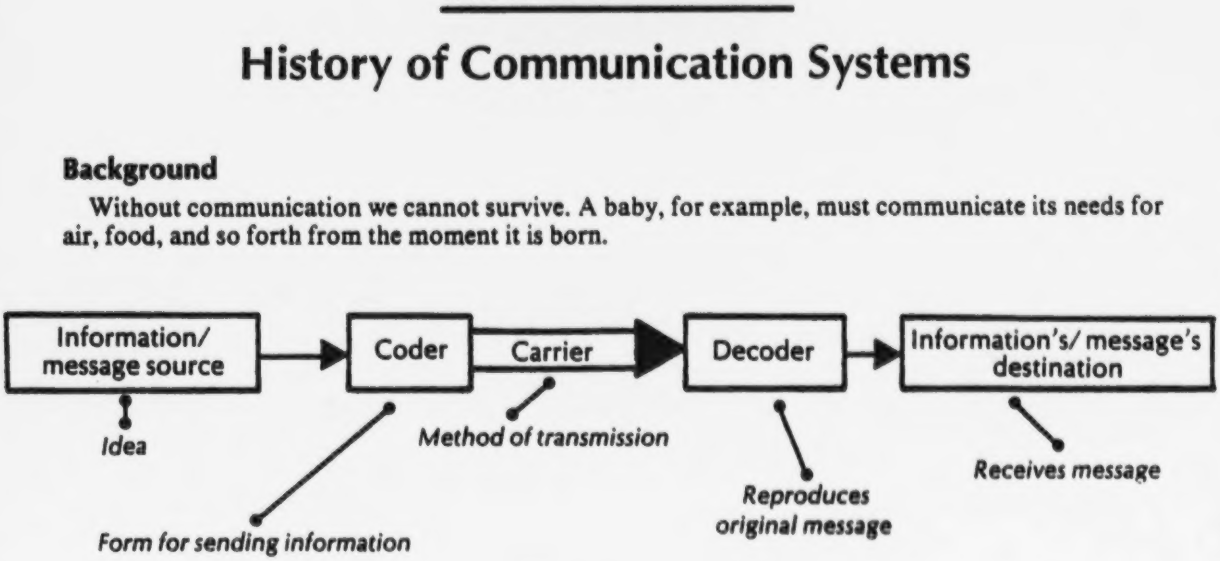
What Is My Name? ____________________

Informational Handout

History of Communication Systems

Background

Without communication we cannot survive. A baby, for example, must communicate its needs for air, food, and so forth from the moment it is born.



Information/ message source
Coder
Carrier
Decoder
Information's/ message's destination
Idea
Method of transmission
Receives message
Reproduces original message
Form for sending information

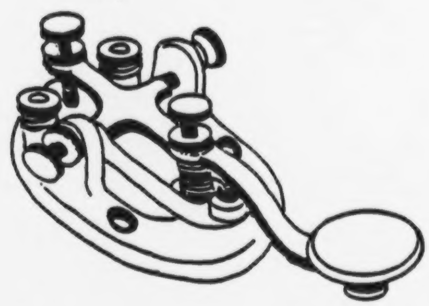
Early History

Cave dwellers felt the need to communicate almost immediately. Grunts and gestures were some of their early systems of communication. When people joined together to form tribes and communities, they had to develop meaningful sounds (language). Many years passed before communication systems were devised to transmit messages over great distances.

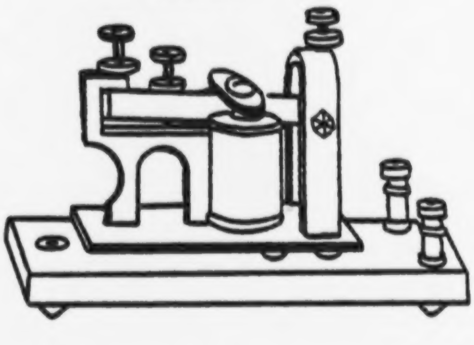
Telegraph

The telegraph opened the door for long distance communication. The telegraph, which was invented by Samuel Morse in 1835, is a method of sending and receiving messages by pulses (dots and dashes). The operator rhythmically touches a device called a key, and then an electrical wire transmits the pulses to a sounder, which clicks in the same manner. The clicks (dots and dashes) correspond to a specific code that represents letters of the alphabet.

Key



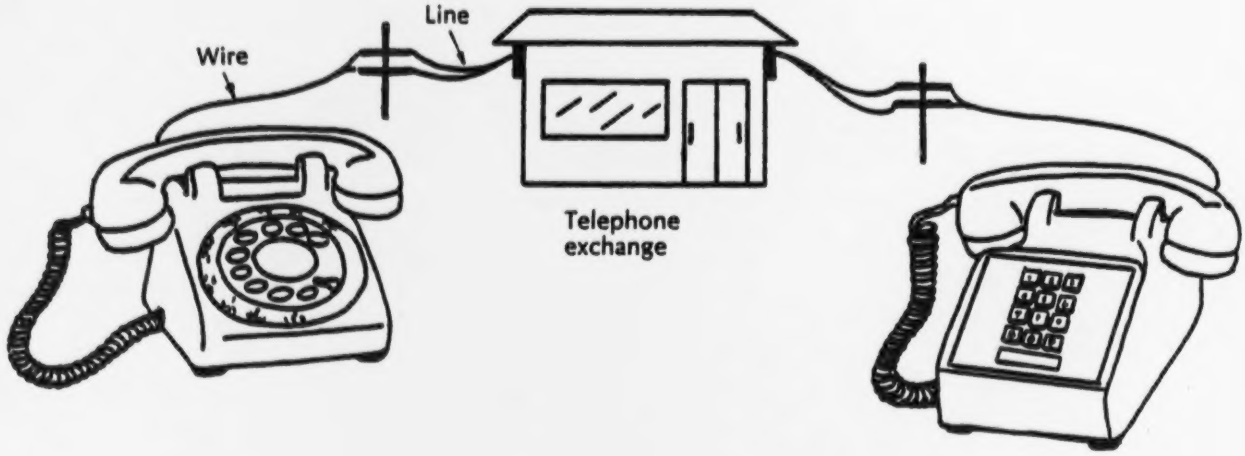
Sounder



Telephone

The telephone is used daily by most people. It was invented and patented by Alexander Graham Bell in 1876. A telephone is simply a transmitter (mouthpiece) connected to a receiver (earpiece) by electrical wires. Sound causes a diaphragm to compress small carbon particles in the mouthpiece. By means of varying pressure on the granules and correspondingly varying current to an electromagnet in the earpiece, the earpiece diaphragm is caused to vibrate and reproduce the voice of the person speaking into the mouthpiece.

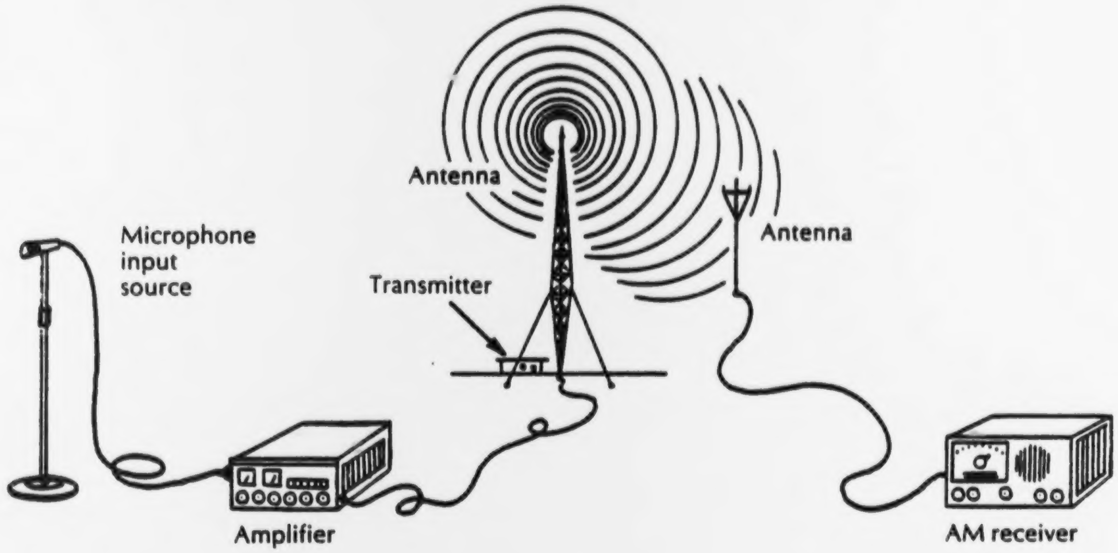
1. Communication is the process of giving and receiving information.
2. The components of a communication system include the following:


Line
Wire
Telephone exchange

Radio

During the early 1900s various kinds of vacuum tubes were developed for detecting and amplifying radio signals. The development of such tubes led to the invention of radio equipment for transmitting and receiving sound. Generally, Reginald Fesseden of the United States is credited with developing the first radio broadcast.

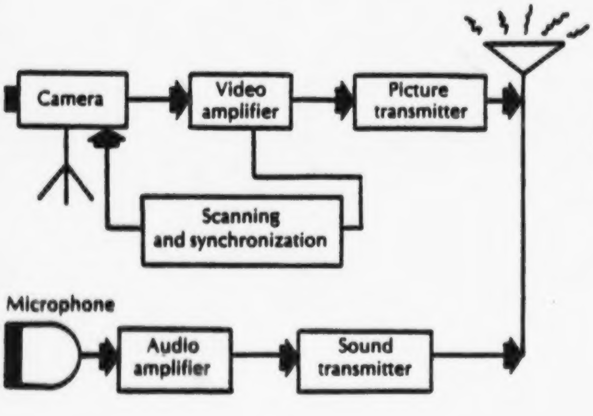
The radio transmitter made it possible to send information with the aid of an antenna. The radio wave travels through the air, and the signal is picked up by a radio receiver.


Antenna
Microphone input source
Antenna
Transmitter
Amplifier
AM receiver

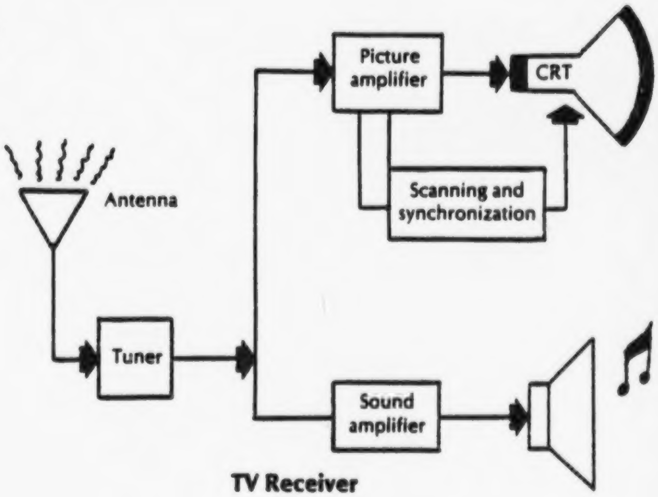
Television

Television is a system of communication which combines the sending and receiving of sound (audio) and image (video) signals. Vladimir Zworykin, John Baird, Charles Jenkins, and others are credited with its development in the 1920s.

Most pictures and sounds received by a television set are beamed from a television station (studio, camera, and other equipment) on electronic signals called electromagnetic waves. The television set (receiver) converts these waves back into pictures and sounds.


Camera
Video amplifier
Picture transmitter
Scanning and synchronization
Microphone
Audio amplifier
Sound transmitter

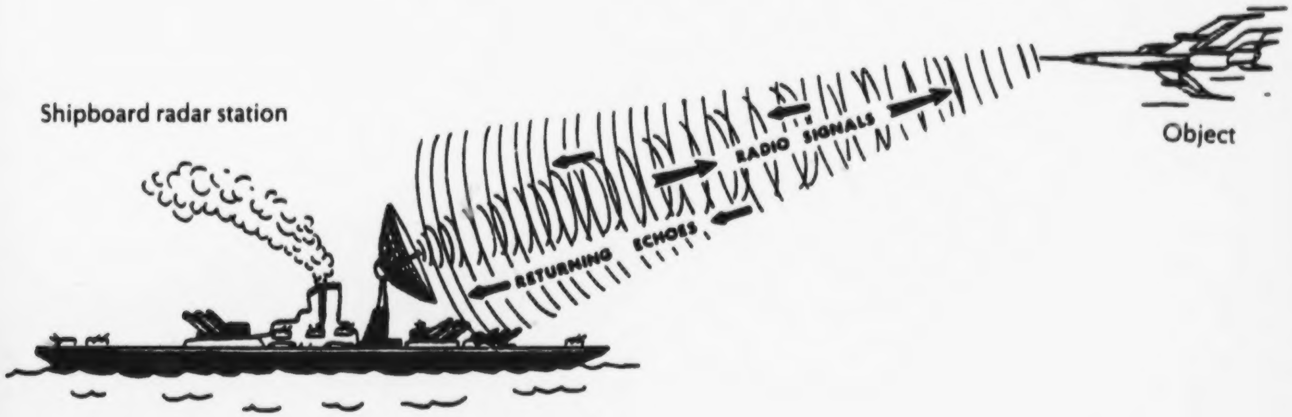
TV Transmitter


Antenna
Tuner
Picture amplifier
CRT
Scanning and synchronization
Sound amplifier

TV Receiver

Radar

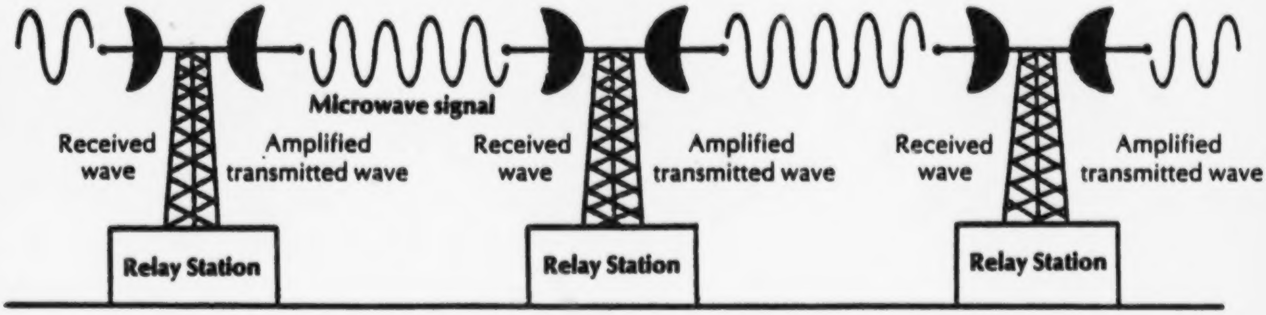
Radar is used in navigational work and in the detection of objects at a distance. The discovery of radar is attributed to L. C. Young and A. H. Taylor in 1922. A simple radar system consists of an aimed antenna which transmits radio signals. These signals hit an object and bounce off, creating an echo. This echo is received and causes a tiny blip to appear on a cathode-ray tube (CRT) screen. The direction, altitude, and distance of the object from the radar station can then be accurately computed. Radar communication systems have been used successfully in both peacetime and wartime.


Shipboard radar station
RADIO SIGNALS
RETURNING ECHOES
Object

Microwave

Microwave systems are a fairly new and efficient method of communication. Microwaves are short, ultrahigh frequency radio signals that travel at the speed of light. They carry telephone, television, telegraph, teleprinter, and other kinds of communications.

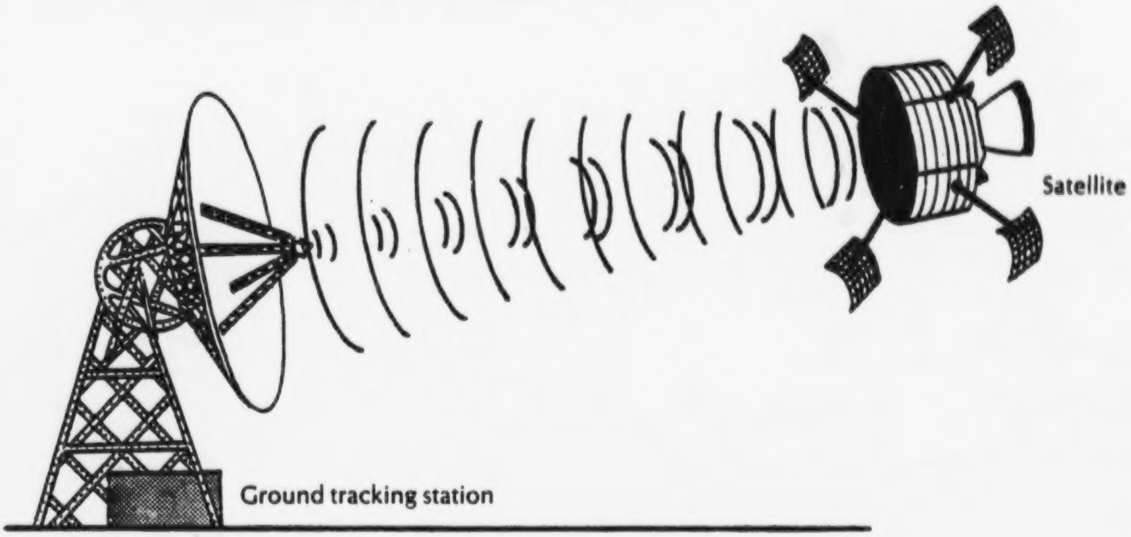
Microwaves can only travel in straight lines and, thus, many relay stations must be used to transmit them over great distances.


Microwave signal
Received wave
Amplified transmitted wave
Received wave
Amplified transmitted wave
Received wave
Amplified transmitted wave
Relay Station
Relay Station
Relay Station

Satellites

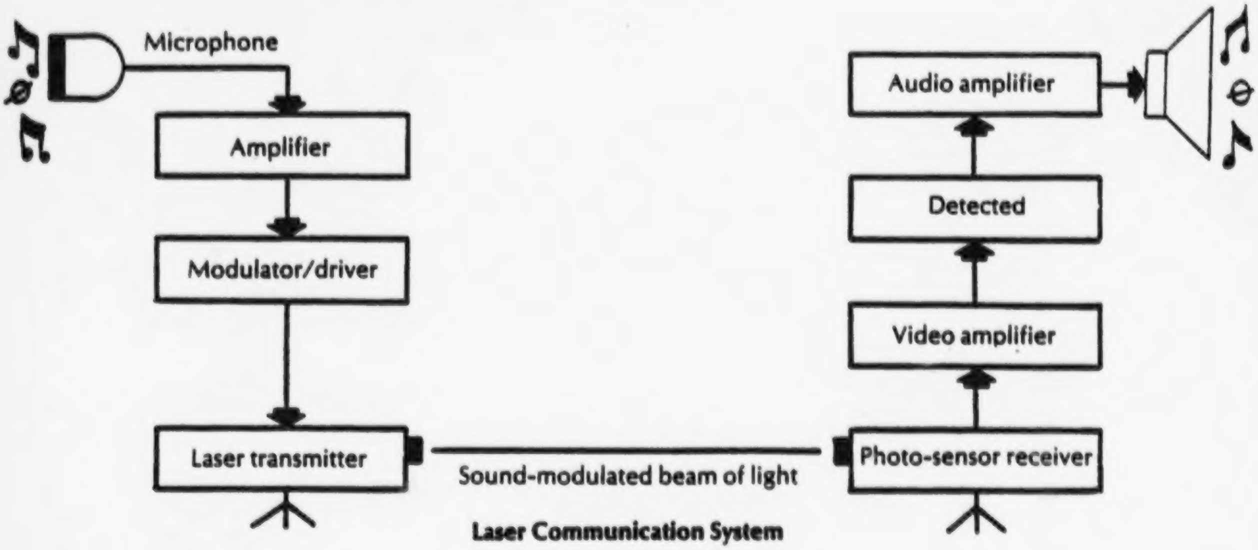
Dozens of satellites are now orbiting the earth, providing hemisphere-to-hemisphere communication, weather observation, and environmental information. The first satellite was launched by the Russians in 1957 and was called *Sputnik*.

Satellites generate their power from the sun to continue receiving and transmitting data for long periods of time. Many satellites gather information on request and send their data to various tracking and communication centers throughout the world.


Satellite
Ground tracking station

Lasers

In 1880, Alexander Graham Bell first proposed several methods of communicating with light. Not until the 1960s, however, was the laser actually developed into a real communication system. Basically, a laser is a device which gives off a beam of light energy that is "ordered or directional" and that has the ability to carry information. The laser has many other applications besides communication; for example, cutting or drilling materials. The reliability of mass communication systems using lasers is still under study.


Microphone
Amplifier
Modulator/driver
Laser transmitter
Sound-modulated beam of light
Photo-sensor receiver
Video amplifier
Detected
Audio amplifier

Laser Communication System

Computers

A basic need of business, industry, and government is the ability to communicate large amounts of information rapidly. Computer communication systems meet this important need. Generally, all computers contain five basic stages: input, output, storage, logic, and control.

The *input* stage provides the means to feed data into the system.

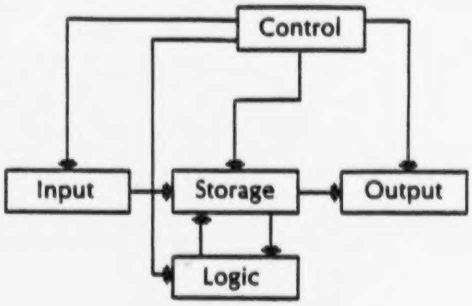
The *output* stage provides the means to remove data from the system.

The *storage* stage holds information for future processing.

The *logic* stage performs the mathematical calculations that are necessary to complete a problem.

The *control* stage contains the "program" of instructions for the stages to follow when completing a job.

The computer is indeed a powerful communication system now and for the future.


Control
Input
Storage
Output
Logic

Computer System

Answer Key
for Unit 22

	T	F		
	1	2	3	4
1.	■			
2.	■			
3.		■		
4.		■		
5.	■			
6.		■		
7.	■			
8.		■		
9.		■		
10.	■			
11.		■		
12.			■	
13.	■			
14.				■
15.			■	
16.	In sync			
17.	Solar			
18.	Hearing			
19.	Message destination			
20.	AM			
21.				
22.				
23.				
24.				
25.				

Know Your Definitions

1. Communication
2. Decoder
3. Radar
4. Radio wave
5. Television
6. Sync (Synchronization)
7. Carrier
8. Modulation
9. Laser
10. Telegraph
11. Information
12. Microwaves

Communication Systems

Radar System

For the sketch and facts, see the Informational Handout.

Source: Manual or programmed keying

Coder: Transmitter

Message carrier: Air

Decoder: Receiver

Message destination: CRT veiwed by operator

Laser System

For the sketch and facts, see the Informational Handout.

Source: Message content

Coder: Amplifier and transmitter

Message carrier: Atmosphere or space

Decoder: Photosensitive receiver

Message destination: Video and audio amplifiers

Answer Key
for Unit 22—Continued

Television System

For the sketch and facts, see the Informational Handout.

Source: Audio and video program

Coder: Audio and video transmitter

Message carrier: Atmosphere or space

Decoder: Audio and video detectors and amplifiers

Message destination: Speakers and cathode-ray tube

Microwave System

For the sketch and facts, see the Informational Handout.

Source: Message content

Coder: UHF signal transmitter

Message carrier: Atmosphere and relay stations

Decoder: Receiver and amplifiers

Message destination: Speaker systems

Activity

Vladimir Zworykin

Unit 23

Occupations in Electricity/Electronics

Title of Unit: Occupations in Electricity/ Electronics

Time Allocated: One week

Unit Goal

To inform the student about the necessity of work, the kinds of skills needed to gain employment, and the specific occupations within the field of electricity/ electronics

Unit Objectives

The student will be able to do the following:

1. Identify the four major occupational areas in the electricity/electronics field.
2. Explain the two kinds of skills classifications that are generally required to gain technical employment.
3. Describe the occupational forecast for technical jobs in the electricity/electronics field.

Evaluation

The student will demonstrate his or her competence in the unit objectives on the basis of performance criteria established by the individual instructors. The criteria may include a combination of oral and written testing procedures.

Instructor's References

Beryle, Milton. *Your Career in the World of Work.* New York: Bobbs-Merrill Co., 1975, chapters 1-13.

Winn, C. S., and L. Heath. *Exploring Occupations in Electricity and Electronics.* New York: McGraw-Hill Book Co., 1975.

Overview

Unit 23 includes the topic of guidance to support and promote students' continuing their studies in this industrial education subject area.

The unit can be introduced by simply discussing the necessity of work. Focus on such reasons as economic needs, self-worth, social contact, and life-style.

Next, assist the students in determining where jobs are and how they are classified. Use the unit's flow chart that depicts the major electricity/electronics occupational families or clusters and identify the four major work areas.

A discussion of the skills that are necessary for employment should be presented; however, equal time should be allocated for discussions of social skills and technical skills.

This unit should conclude with an overview of the present occupational forecast for this technical field.

Suggested Presentation Hints/Methodology

Use this unit as a basic guideline for presenting the curriculum; however, note the following:

1. This unit was included to supplement the school's guidance program; hence, draw on the latter's resources for current films, tapes, or any other audiovisual materials that might be used.
2. Slides can be taken of the specific work areas within each cluster to increase the student's awareness of specific job descriptions. From viewing the slides, the student will have greater exposure to the many different kinds of technical jobs that can be found in the four major occupational families in the electricity/electronics field.
3. The latest editions of the *Occupational Outlook Handbook* and the *Dictionary of Occupational Titles* should be used to keep abreast of current information about careers in the electricity/electronics field. For more information of this nature, contact the U.S. Government Printing Office, Washington, DC 20401.
4. When gathering data for an occupational forecast, try to procure a copy of the latest *Area Manpower Report*. This report will contain economic outlook projections, trends, population growth, and so forth. It is available at both the federal and state levels, so check with the proper government employment development agency in your area for further information.

Supplemental Activities and Demonstrations

The following supplemental activities and demonstrations are suggested for use in presenting the curriculum:

1. In addition to using occupational forecasts, which primarily refer to future needs, have students analyze a major urban newspaper's Help

Wanted ads. These kinds of ads are useful for identifying immediate job availability.

2. In any discussion of jobs, the students should be advised that employment decline is found mostly in those jobs that require less education and training. Have them verbally describe some of these jobs, by title, and list them on the chalkboard.
3. Women play an important part in the world of work. Indicate that many women work in the electricity/electronics industry and that in some companies they outnumber the men. Impress on the students that during the past 25 years, more than half of all the new workers added to the American labor force have been women.

Instructional Unit Contents

1. Unit Outline (overhead)
2. Pretest and Post-test (keyed)
3. Technical Glossary
4. Work Sheet (vocabulary)—Word Decoding
5. Work Sheet—Necessity of Work
6. Activity
7. Work Sheet—Career Research in the Electricity/Electronics Field
8. Informational Handout (Employment Forecast and Kinds of Training)
9. Answer Key for Unit 23

Unit 23

Occupations in Electricity/Electronics

(Lecture Outline)

A. Necessity of Work

B. Where Are the Jobs?
  1. Cluster breakdown for the electricity/electronics field
    a. Electronics manufacturing and services
    b. Electrical servicing and repair
    c. Electrical construction
    d. Miscellaneous technical occupations
  2. Skills necessary for employment
    a. Technical skills
    b. Social skills

C. Occupational Forecast

Test number ________

Examination for Unit 23

Occupations in Electricity and Electronics

Write your answers to the questions on the answer sheet. Fill in the box that corresponds to the correct answer to the question. Each question has only one correct answer.

1. The main reason for work is to earn enough money to buy a car and pay for the insurance. (T-F)
2. An electricity/electronics occupational cluster refers to a major family of related occupations that may have a common function. (T-F)
3. All jobs require about the same training and preparation. (T-F)
4. The way individuals respond to or feel about their careers has a direct bearing on their overall satisfaction with life. (T-F)
5. An occupation is important only during the workday and has little influence on one's personal life. (T-F)
6. Women are generally unsuccessful in electronics occupations because of the physical dexterity required. (T-F)
7. Most adults in our society are well satisfied with their incomes and life-styles and indicate that career planning is not that essential to obtaining career goals. (T-F)
8. A quick method for checking the demand in a major work area is to read the Help Wanted section of the local newspaper. (T-F)
9. After a worker finds another employee's mistake, the worker should force that person to admit it and then report the individual to management. (T-F)
10. People who go into the "assembly" occupational area must have a strong professional-type training background. (T-F)
11. Society's role expectations of males and females should be followed because certain careers are just for men and certain careers are just for women. (T-F)
12. Pressure from a person's family and friends can have a major impact on his or her career choice. (T-F)
13. If a person makes a lot of money, the person does not need to like her or his occupation. (T-F)
14. Everyone has a basic need to feel wanted and worthwhile. (T-F)
15. If a person wants to have friends on the job, he or she should do most of the talking during a conversation. (T-F)

Technical Glossary

Cluster—A group of occupations or jobs that are related or joined together by having similar characteristics or a common purpose.

Competency—The skill or knowledge a person needs to perform a particular job successfully.

Electrical construction—That cluster of electrical occupations involved with wiring power circuits and auxiliary electrical devices into a building or structure. An electrician is an example of the type of individual found within this job cluster.

Repair—That cluster of electrical occupations involved with the repair, installation, wiring, fabrication, adjustment, and maintenance of electrical devices. Sample occupations can be found in the electrical utility, telephone, and appliance repair industries.

Electronics manufacturing and servicing—That cluster of electronics occupations involved with supervising, design, assembly, inspection, testing, servicing, and fabrication of electronic devices. Occupations such as assemblers, testers, technicians, and printed circuit board processors are found within this cluster.

Forecast—A projection or educated guess, based on surveys, trends, and studies, of the future needs of an industry or occupation. Forecasts are often completed to point out the job needs (openings available or oversupply of qualified people) for a particular area or industry.

Highly skilled—Said of an individual who, through proper training, has obtained many specialized and complex skills or abilities. This individual is usually very much in demand by industry and is paid an excellent salary. Generally, this person will have completed at least two years of college or technical training.

Miscellaneous technical operations—That cluster of electronics occupations which includes various specialized jobs within the field of electronics. Occupations in this cluster include engineers, teachers, vocational counselors, and radio/TV broadcasters.

Occupation—The job or type of work that a person performs to earn a living.

Professional—An individual who has spent many years in preparation for a rewarding and highly responsible job. This type of individual generally completes four or more years of college education and often donates many hours of work to gain experience. When hired, a professional can expect a very high salary to offset the years of training required. Doctors, lawyers, and engineers are classified as professionals.

Semiskilled—Said of an individual who has acquired a sufficient number of skills to make her or him readily employable in many occupations. These individuals can usually plan on receiving additional training on the job or at night or at a technical school to help them to advance to a better job. Semiskilled jobs usually require at least a high school education.

Skill—The ability to perform a task or job by applying learned knowledge and/or physical dexterity.

Social skills—The behavior or manners needed to work, communicate, and get along with other people. Social skills involve such things as working efficiently with other people, even if the person doesn't like or know them; using time efficiently; dealing with frustration maturely; and using acceptable language.

Technical skill—A specialized skill, ability, or knowledge required to perform a job or technical task. Soldering, measuring voltage, and applying knowledge of electronics to solve a circuit problem are examples of technical skills.

Unskilled—Said of a worker who possesses a minimal number of skills or abilities. Unskilled workers usually are paid very low wages and perform very simple, repetitive tasks. Unskilled workers generally have not finished high school.

Work—The labor, tasks, or duties that one performs in exchange for payment (wages, goods, and so forth).

Score ________ Name ____________________

Grade ________ Date ____________________

Period ____________________

Work Sheet

Word Decoding

The words below have little meaning until they are decoded. Each letter represents another letter in the alphabet. The example will get you started in decoding the other scrambled terms on the work sheet.

Example: A. LJYAAY A. CAREER

1. BUYALJDE 1. ____________________
2. LUIVAEATLO 2. ____________________
3. DULRJH DGRHH 3. ____________________
4. ULLFVJERUT 4. ____________________
5. VYUBADDRUTJH 5. ____________________
6. LHFDEAY 6. ____________________
7. MUYG 7. ____________________
8. EALQTRLJH DGRHH 8. ____________________
9. DAYZRLRTC JTP YAVJRY 9. ____________________
10. AHALEYUTRL IJTFBJLEFYRTC 10. ____________________

Score ________ Name ________________

Grade ________ Date ________________

Period ________________

Work Sheet

Necessity of Work

The main reasons that people work are indicated below. In the space provided, explain briefly what is meant by each topic title.

1. Economic reasons
   (Hint: money, luxuries, and so on)

2. Social recognition
   (Hint: contact, friendships, and so on)

3. Emotional satisfaction
   (Hint: identity, self-worth, and so on)

4. Which of the above would be the main reason that you would want to work? Be honest!

Score ________

Grade________

Name ______________________

Date ______________________

Period ______________________

Work Sheet

Activity

An important part of exploring occupational information involves the collection of specific career data which can be used in forming an appropriate career goal.

Use the attached electricity/electronics organizational cluster chart and all other career resource materials available in the classroom to complete the following occupational profile.

Select from any major work area found within a particular cluster an occupation which interests you and use the format below as a guide. Submit a neat profile and answer all questions.

Name______________________ Due date__________

I. Research profile number ______________________

II. Major work area ______________________

III. Basic duties and responsibilities

IV. Specific working conditions

V. Salary range ______________________

VI. Present and future occupational outlook in this area

VII. Educational and/or special training requirements

VIII. Availability of local educational or training institutions

IX. Advantages and disadvantages of this career choice

X. Sources of information used in completing this profile

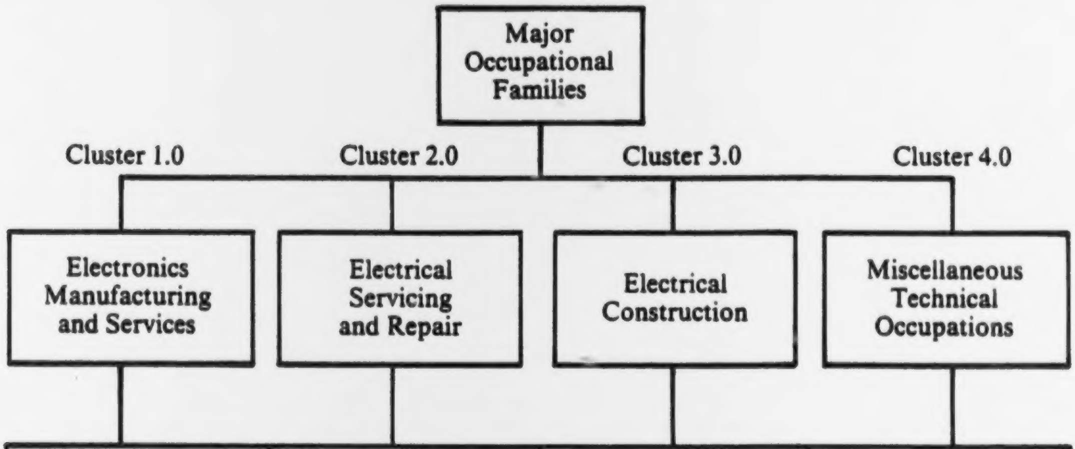
Score ________ Name ____________________

Grade ________ Date ____________________

Period ____________________

Work Sheet

Career Research in the Electricity/Electronics Field


Major Occupational Families
Cluster 1.0
Cluster 2.0
Cluster 3.0
Cluster 4.0
Electronics Manufacturing and Services
Electrical Servicing and Repair
Electrical Construction
Miscellaneous Technical Occupations

1.1 Processing	2.1 Electrical instruments	3.1 Electricians	4.1 Engineering
1.2 Assembly preparation	2.2 Coils, motors, and generators	3.2	4.2 Education
1.3 Assembly	2.3 Appliances and fixtures	3.3	4.3 Radio/television broadcasting
1.4 Inspection and testing	2.4 Communication equipment	3.4	4.4
1.5 Setup and maintenance	2.5 Transportation equipment	3.5	4.5
1.6 Technician	2.6 Electrical utilities	3.6	4.6
1.7 Special occupations	2.7 Miscellaneous electrical equipment	3.7	4.7
1.8 Supervision	2.8	3.8	4.8
1.9 Repair and servicing of electronic equipment	2.9	3.9	4.9

Score ________

Grade ________

Name ____________________

Date ____________________

Period ____________________

Informational Handout

Employment Forecast and Kinds of Training

A variety of opportunities for technical employment are available in California if one has the necessary skills and/or education. Employers are seeking individuals who possess higher levels of technical education, because many occupations are complex and require great skill.

Employment Forecast

Entry-level occupations that require a high school education, including some technical training, still demand basic or fundamental skills. Employers agree that young people who have acquired skills and a good education will have a better opportunity for satisfying employment, greater wages, and employment security.

Employment in the electricity/electronics field and its related occupational families is expected to increase faster than the average for all industries through the middle 1990s. In addition to the occupations resulting from employment growth, large numbers of openings will arise through normal vacancies created by retirement, death, and employees' changing occupations.

Although employment in the electricity/electronics field is expected to grow over the next few years, it may fluctuate from year to year among occupational clusters and/or major work areas.

Preparation

Provided below are summaries of the basic requirements for education and training for employment in (1) unskilled, semiskilled, and skilled work; (2) highly skilled work; and (3) management and professional work.

Unskilled, Semiskilled, and Skilled work

Graduation from high school or a regional occupational center (ROC) with as many electives as possible in math, drafting, metals, and, of course, electricity/electronics. These basic skills will be of immediate help in entering an industry. Read magazines and books on basic electricity/electronics. On-the-job training is part of one's employment. Night school or a home study course can be helpful in getting promotions or a better paying job.

Highly Skilled and Some Professional Work

Graduation from high school with as many electives as possible in math, science, drafting, metals, and, of course, electricity/electronics. Additional technical training can be obtained at a technical institute, at a community college, and/or in a military training program. Many advanced training institutions have a placement service to assist students in locating immediate employment after graduation. A certificate or degree is usually granted on successful completion of a one- to two-year program.

Management and Professional Work

Graduation from high school with as many electives as possible in math, science, electricity/electronics, and other college preparatory courses. Professional training is offered in a college or university and requires a time commitment of about four years. Entrance requirements for colleges and universities vary greatly. Consult with your counselor to make sure you can meet the requirements of the college of your choice (as well as those for graduation from high school). Keep in mind that for some engineering careers, two or more years of graduate work are necessary.

Answer Key
for Unit 23

	T	F		
	1	2	3	4
1.		■		
2.	■			
3.		■		
4.	■			
5.		■		
6.		■		
7.		■		
8.	■			
9.		■		
10.		■		
11.		■		
12.	■			
13.		■		
14.	■			
15.		■		
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
25.				

Word Decoding

1. Forecast
2. Competency
3. Social skill
4. Occupation
5. Professional
6. Cluster
7. Work
8. Technical skill
9. Servicing and repair
10. Electronic manufacturing

Necessity of Work

1. (Answers will vary.)
2. (Answers will vary.)
3. (Answers will vary.)

Activity

(Answers will vary.)

Unit 24

Opportunities in Electricity/Electronics

Title of Unit: Opportunities in Electricity/Electronics

Time Allocated: One week

Unit Goal

To further acquaint the student with occupational exploration

Unit Objectives

The student will be able to do the following:

1. Indicate in writing or verbally those methods of job selection that are typically used to research a possible occupational choice.
2. Select one occupation that meets his or her abilities, interests, and attitudes.
3. Explain the essential preparation or training that is needed to fulfill the qualifications for the specific occupation he or she has selected.

Evaluation

The student will demonstrate his or her competence in the unit objectives on the basis of performance criteria established by the individual instructors. The criteria may include a combination of oral and written testing procedures.

Instructor's References

Beryle, Milton. *Your Career in the World of Work.* New York: Bobbs-Merrill Co., 1975, chapters 1-13.

Winn, C. S., and L. Heath. *Exploring Occupations in Electricity and Electronics.* New York: McGraw-Hill Book Co., 1975.

Overview

Unit 24 represents a natural culmination point for this level. It also can be thought of as the "hook" in getting the students interested in the field of electricity/electronics.

The introductory topic deals with self-assessment and its relationship to the overall job selection process. The kind of person "I" represent today and the type of person "I" desire to be are essential factors in analyzing the selection process, along with such considerations as salary, qualifications, and working conditions.

The next topic includes an overview of basic occupational research techniques and methods for obtaining additional occupational information.

Unit 24 can be incorporated into Unit 23 or presented separately at the instructor's discretion.

Suggested Presentation Hints/Methodology

Use this unit as a basic guideline for presenting the curriculum; however, note the following:

1. Check the yellow pages of the telephone book for electronic equipment manufacturing firms. Locate a company that will allow a school field trip through its facilities and take time with the company's representative to describe the kinds of things that the students would be interested in viewing.
2. Reemphasize the value of work in a person's life. Review the idea that most people work for economic, social, and psychological (emotional) reasons. Advise students to be honest and realistic when completing the personal inventories in this unit.
3. Check with the school's guidance counselor or career center for aptitude and interest inventory tests. These tests can help students to develop valuable insight into their strengths and weaknesses and likes and dislikes. The results of these tests, combined with some tough self-evaluation, can help point the students in the right direction.
4. Indicate to the students that interest inventory tests do not measure motivation, personality, or ambition. They do show fairly accurately what an individual might do or would like to do, but the individual must decide what he or she actually will do.

Supplemental Activities and Demonstrations

The following supplemental activities and demonstrations are suggested for use in presenting the curriculum:

1. Obtain free of charge from the U.S. Department of Education information on financial and other assistance. Contact the U.S. Department of

Education, 400 Maryland Ave., S.W., Washington, DC 20202.

2. To obtain information about apprenticeship programs, write to the Bureau of Apprenticeship and Training, U.S. Department of Labor, Office of Comprehensive Employment, Employment and Training Administration, 200 Constitution Ave., N.W., Room South 2322, Washington, DC 20210.
3. For more information on career training programs and tips on job finding, contact the Employment Training Administration, U.S. Department of Labor, 200 Constitution Ave., N.W., Room South 2322, Washington, DC 20210.

Instructional Module Contents

1. Unit Outline (overhead)
2. Pretest and Post-test (keyed)
3. Technical Glossary
4. Work Sheet (vocabulary)—Know Your Definitions
5. Work Sheet—Personal Profile Analysis
6. Activity
7. Informational Handout (Interest and Ability Inventory)
8. Answer Key for Unit 24

Unit 24

Opportunities in Electricity/Electronics

(Lecture Outline)

A. Personal Interest Inventory

B. Possible Career Choices

Test number ________

Examination for Unit 24

Opportunities in Electricity/Electronics

Write your answers to the questions on the answer sheet. Fill in the box that corresponds to the correct answer to the question. Each question has only one correct answer.

1. Career research is the process of carefully studying information about many different occupations. (T-F)
2. The *Dictionary of Occupational Titles* is helpful in learning how to spell the name of or define an occupation. (T-F)
3. Choosing an occupation is generally easy and requires very little thought. (T-F)
4. Personal abilities are of little importance in selecting a career. (T-F)
5. A desire to be clean and neat in appearance should have nothing to do with a career choice. (T-F)
6. Part of understanding oneself includes evaluating one's interests. (T-F)
7. Selecting an occupation is mostly a matter of luck. (T-F)
8. When selecting a career goal, a person should determine what the future needs in that field might be. (T-F)
9. The educational or training requirements of an occupation can be disregarded if an individual knows the "right" people. (T-F)
10. School grades, attendance, and times tardy are usually ignored by potential employers. (T-F)

Technical Glossary

Aptitude test—A type of test used to assist in measuring or predicting one's probable success and ability in special areas. A common aptitude test is the *Scholastic Aptitude Test (SAT)*, a college entrance examination used to predict learning success in college. The *Armed Services Vocational Aptitude Battery (ASVAB)* tests abilities in vocational areas or subjects.

Interest inventory—A research questionnaire or test used to determine or identify personal interests. This information can then be used in selecting an occupational field or jobs which incorporate the identified interests.

Occupational search—The process of studying and surveying many occupations and identifying major duties, requirements, working conditions, wages, employment forecasts, advancement possibilities, and training needs.

Qualifications—A list of achievements, accomplishments, and qualities an employer will look for when considering an individual for employment.

Self-evaluation—An honest, hard look at oneself to determine personal strengths, weaknesses, problems, and concerns. An honest self-evaluation can help in setting a realistic occupational goal.

Score ________

Grade________

Name ______________________

Date ______________________

Period ______________________

Work Sheet

Know Your Definitions

Write in your own words a short definition for each of the following terms.

1. Occupational search:

2. Qualifications:

3. Self-evaluation:

4. Interest inventory:

5. Aptitude test:

Score ________

Grade________

Name ________________________

Date ________________________

Period ________________________

Work Sheet

Personal Profile Analysis

Everyone wants to be successful, but to achieve this goal, a person must plan his or her occupational choice and assess his or her abilities, interests, and attitudes in a realistic manner. To do so, an individual must know herself or himself. Complete the following personal profile in detail; be honest in evaluating your assets and liabilities.

Personality

Rate yourself on the personality traits listed below. Place a check (✓) in the most appropriate column for each trait.

Personality Profile

Trait	Good	Fair	Poor
Attitude			
Courtesy			
Dependability			
Drive			
Health			
Honesty			
Humor			
Initiative			
Loyalty			
Morality			
Neatness			
Personal appearance			
Pleasantness			
Punctuality			
Sincerity			
Tact			
Temperament			

Personality Profile Analysis:

My personality has several strong points as indicated on the Personality Profile. Listed below are what I consider my most attractive traits:

1. ________________________ 3 ________________________

2. ________________________ 4. ________________________

I have also discovered a need to improve the following traits:

1. ______________________ 3. ______________________

2. ______________________ 4. ______________________

Interests

The hobbies that interest me the most are as follows:

1. ______________________ 3. ______________________

2. ______________________ 4. ______________________

The classes in school that are the most exciting to me are as follows:

1. ______________________ 3. ______________________

2. ______________________ 4. ______________________

I have always liked to work with (check one or more):

People ☐ Things ☐ Ideas ☐

Abilities

My main scholastic strengths are as follows (check one or more):

Reading ☐ Verbal ☐ Mechanical ☐ Mathematical ☐

My overall grade point average in high school is __________.

Values

Indicate your ranking of the values listed below by placing a number from 1 to 10 beside each item. Use a number only once. Place 1 next to the item you consider the most important, 2 next to the item you consider the second most important, and so on.

Fame _____ Family _____

Health _____ Money _____

Power _____ Religion _____

Human values _____ Social acceptance _____

Creativity _____ Artistic ability _____

Decision

After considering the information on this profile and other career assessment data, I feel that I would like to explore further careers related to ______________________________.

Score ________ Name ____________________

Grade ________ Date ____________________

Period ____________________

Work Sheet

Activity

List three places where you can find information about occupations.

1. ________________________________

2. ________________________________

3. ________________________________

In the spaces provided, indicate three possible occupational choices for yourself and the training requirements for entering each. Also indicate under which cluster each occupation can be found.

1. Occupation ____________________ Cluster ____________

   Basic training requirements ____________________________

2. Occupation ____________________ Cluster ____________

   Basic training requirements ____________________________

3. Occupation ____________________ Cluster ____________

   Basic training requirements ____________________________

In the spaces provided, indicate the present and expected needs for workers for the three occupations indicated above.

1. The current need for workers in Occupation 1 is:

   a. Locally ____________________________

   b. Statewide ____________________________

   c. Nationally ____________________________

   Comments ____

   The expected future need for workers in Occupation 1 is:

   a. Locally ____________________________

   b. Statewide ____________________________

c. Nationally__________________________________

Comments____

2. The current need for workers Occupation 2 is:

a. Locally __________________________________

b. Statewide __________________________________

c. Nationally__________________________________

Comments____

The expected future need for workers in Occupation 2 is:

a. Locally __________________________________

b. Statewide __________________________________

c. Nationally__________________________________

Comments____

3. The current need for workers in Occupation 3 is:

a. Locally __________________________________

b. Statewide __________________________________

c. Nationally__________________________________

Comments____

The expected future need for workers in Occupation 3 is:

a. Locally __________________________________

b. Statewide __________________________________

c. Nationally__________________________________

Comments____

I used the following resource materials to verify my answers for this Activity:

1. Title ____ page(s) ________
2. Title ____ page(s) ________
3. Title ____ page(s) ________

Informational Handout

Interest and Ability Inventory

Having an interest in an occupation is important, but it just might not be enough. You must also have the ability or a combination of abilities to fulfill your career goal.

Have you ever analyzed both your interests and abilities? To be successful in selecting the proper occupation, you must do the following:

1. Determine your overall likes and dislikes.
2. Determine your talents in terms of performance strengths and weaknesses.

In the following inventory, place a check (✓) in the appropriate column for each item to indicate your feelings about each activity.

Activity	Really enjoy	Like	Maybe?	Dislike	Hate it
1. Being my own boss					
2. Working alone					
3. Working with equipment					
4. Traveling a lot					
5. Making accurate measurements					
6. Working on a project					
7. Analyzing costs					
8. Determining data					
9. Supervising others					
10. Preparing reports					
11. Repairing objects					
12. Making things in a shop					
13. Working with tools					
14. Selling things					
15. Speaking before groups					
16. Following others					
17. Directing others					
18. Reading books					
19. Studying					
20. Attending school					
21. Keeping accurate records or notes					
22. Collecting bills					
23. Working to close specifications					
24. Doing the same work all the time					
25. Getting up early					
26. Sleeping late					
27. Working at night					
28. Being imaginative and creative					
29. Doing outdoor work					
30. Doing desk work					
31. Being neat and attractive in appearance					
32. Working as part of a team					
33. Being healthy					

Place a check (✓) in each column to indicate how skilled you are in each area.

Activity	Highly skilled	Skilled	Average	Somewhat unskilled	Totally unskilled
34. Able to read or play music					
35. Able to study and solve problems					
36. Artistic					
37. Accurate in detail work					
38. Good in grammar and spelling					
39. Good in science and mathematics					
40. Concerned about people's problems					
41. Able to type accurately					
42. Able to work under pressure					
43. Comfortable meeting new people					
44. Seldom tardy or absent					
45. Well coordinated					

Now review your answers. What are your strongest interests? What are your strongest skills? What careers might these suggest?

Getting to know yourself a little better is the first step in career awareness. You will do a much better job and be a much happier person if you really enjoy your occupation.

Answer Key for Unit 24

	T	F		
	1	2	3	4
1.	■			
2.		■		
3.		■		
4.		■		
5.		■		
6.	■			
7.		■		
8.	■			
9.		■		
10.		■		
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
25.				

Know Your Definitions

1. (Answers will vary.)
2. (Answers will vary.)
3. (Answers will vary.)
4. (Answers will vary.)
5. (Answers will vary.)

Personal Profile Analysis

(Answers will vary.)

Activity

1. *Dictionary of Occupational Titles*
2. *Occupational Outlook Handbook*
3. *California Occupational Guides*

(Answers will vary for the remainder of the questions.)

Publications Available from the Department of Education

This publication is one of over 650 that are available from the California State Department of Education. Some of the more recent publications or those most widely used are the following:

ISBN	Title (Date of publication)	Price
0-8011-0395-9	Apprenticeship and the Blue Collar System: Putting Women on the Right Track (1982)	$10.00
0-8011-0300-2	Apprenticeship Handbook for Educators (1974)	3.50
0-8011-0783-0	California Private School Directory, 1988-89 (1988)	14.00
0-8011-0747-4	California Public School Directory (1989)	14.00
0-8011-0748-2	California School Accounting Manual (1988)	8.00
0-8011-0715-6	California Women: Activities Guide, K—12 (1988)	3.50
0-8011-0488-2	Caught in the Middle: Educational Reform for Young Adolescents in California Public Schools (1987)	5.00
0-8011-0760-1	Celebrating the National Reading Initiative (1989)	6.75
0-8011-0797-0	Desktop Publishing Guidelines (1989)	4.00
0-8011-0462-9	Electricity/Electronics Curriculum Guide, Phase II, Level I (1985)	15.00
0-8011-0802-0	Electricity/Electronics Curriculum Guide, Phase II, Level II (1989)	15.00
0-8011-0041-0	English–Language Arts Framework for California Public Schools (1987)	3.00
0-8011-0731-8	English–Language Arts Model Curriculum Guide, K—8 (1988)	3.00
0-8011-0786-5	Enrichment Opportunities Guide: A Resource for Teachers and Students in Mathematics and Science (1988)	8.75
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